ASTRONOMY

September 1981
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Charting the Infrared Universe

Introduction to Deep-Sky Observing

Comet Halley 240 B.C. — 1986 A.D.

Comet West 1976

Meade System 2000

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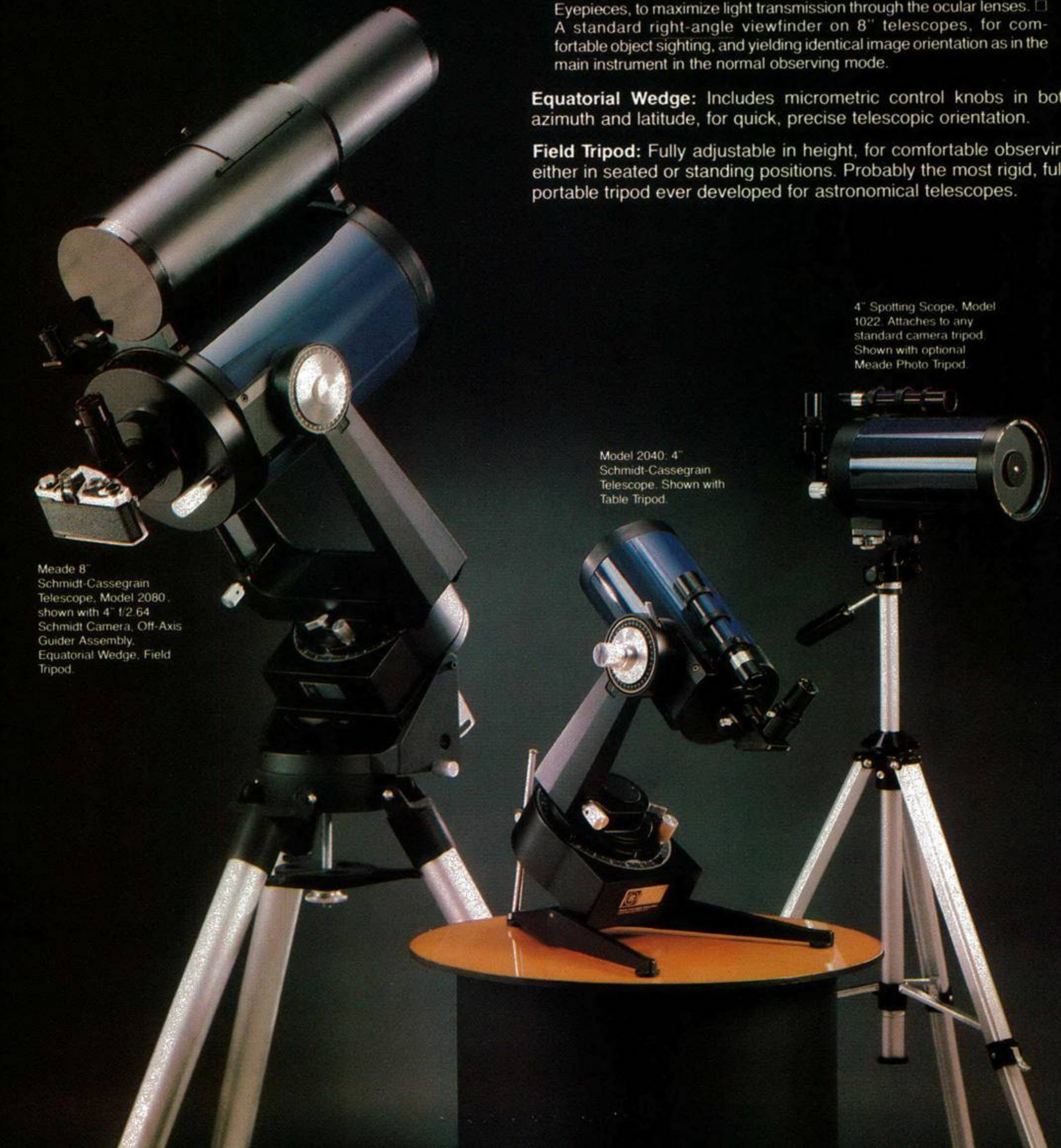

4" Spotting Scope, Model 1022. Attaches to any standard camera tripod. Shown with optional Meade Photo Tripod.

Model 2040: 4" Schmidt-Cassegrain Telescope. Shown with Table Tripod.

Meade 8" Schmidt-Cassegrain Telescope, Model 2080, shown with 4" f/2.64 Schmidt Camera, Off-Axis Guider Assembly, Equatorial Wedge, Field Tripod.

Schmidt-Cassegrains

The System: Perhaps most importantly of all, Meade System 2000 Schmidt-Cassegrains are part of a wide and versatile system: the amazing 4" f/2.64 Schmidt Camera; 4" Schmidt-Cassegrain Photo-Guide Telescope with Illuminated Reticle Eyepiece; Dual-Axis Drive Corrector, and more — all of which attach easily and directly to 8" models.

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Model 2040:	
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Model 2080:	
8" Schmidt-Cassegrain Telescope with Fork Mount ......Base Price	**865**
Equatorial Wedge 4"/8"	**60**
Field Tripod 4"/8"	**160**
Table Tripod 4"	**40**
Table Tripod 8"	**50**
Model 1020: 1000mm f/10 Telephoto Lens	**325**
Model 1022: 4" Spotting Scope	**395**
Meade Photo Tripod for Models 1020 or 1022	**50**
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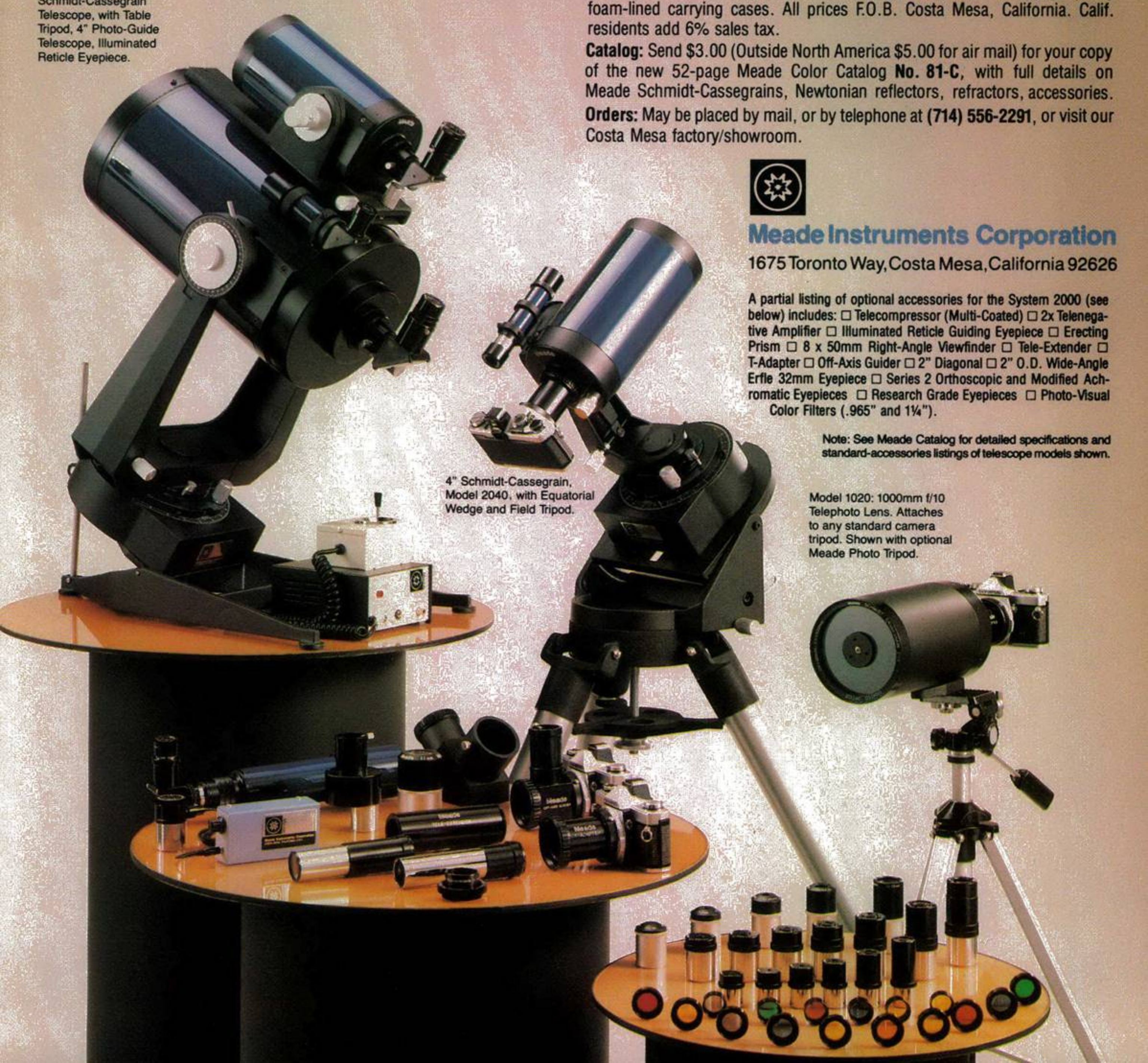
A partial listing of optional accessories for the System 2000 (see below) includes: ☐ Telecompressor (Multi-Coated) ☐ 2x Telenegative Amplifier ☐ Illuminated Reticle Guiding Eyepiece ☐ Erecting Prism ☐ 8 x 50mm Right-Angle Viewfinder ☐ Tele-Extender ☐ T-Adapter ☐ Off-Axis Guider ☐ 2" Diagonal ☐ 2" O.D. Wide-Angle Erfle 32mm Eyepiece ☐ Series 2 Orthoscopic and Modified Achromatic Eyepieces ☐ Research Grade Eyepieces ☐ Photo-Visual Color Filters (.965" and 1¼").

Note: See Meade Catalog for detailed specifications and standard-accessories listings of telescope models shown.



Model 2080: 8" Schmidt-Cassegrain Telescope, with Table Tripod, 4" Photo-Guide Telescope, Illuminated Reticle Eyepiece.

4" Schmidt-Cassegrain, Model 2040, with Equatorial Wedge and Field Tripod.

Model 1020: 1000mm f/10 Telephoto Lens. Attaches to any standard camera tripod. Shown with optional Meade Photo Tripod.

ASTRONOMY

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Cover: In early 1976, Comet West awed observers during its two-week passage across pre-dawn skies. Comet Halley, due to return in 1986, may not be quite as impressive, but is nevertheless eagerly anticipated. Photograph by Ronald Royer. These pages: A star party with the local astronomy club gives you an opportunity to learn observing skills and use a variety of telescopes. Photograph of a Chicago Astronomical Society star party by Emery Hildebrand.

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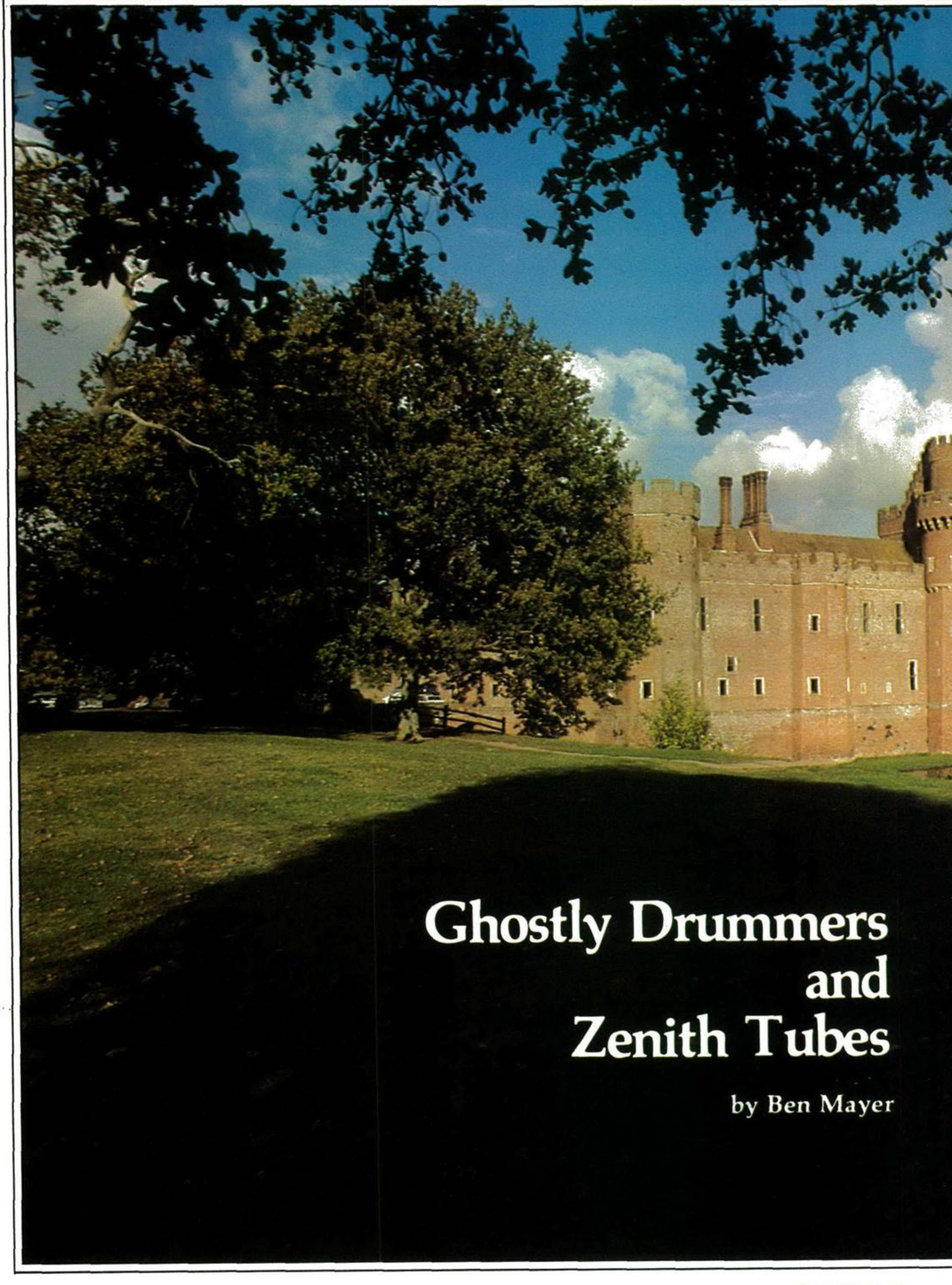
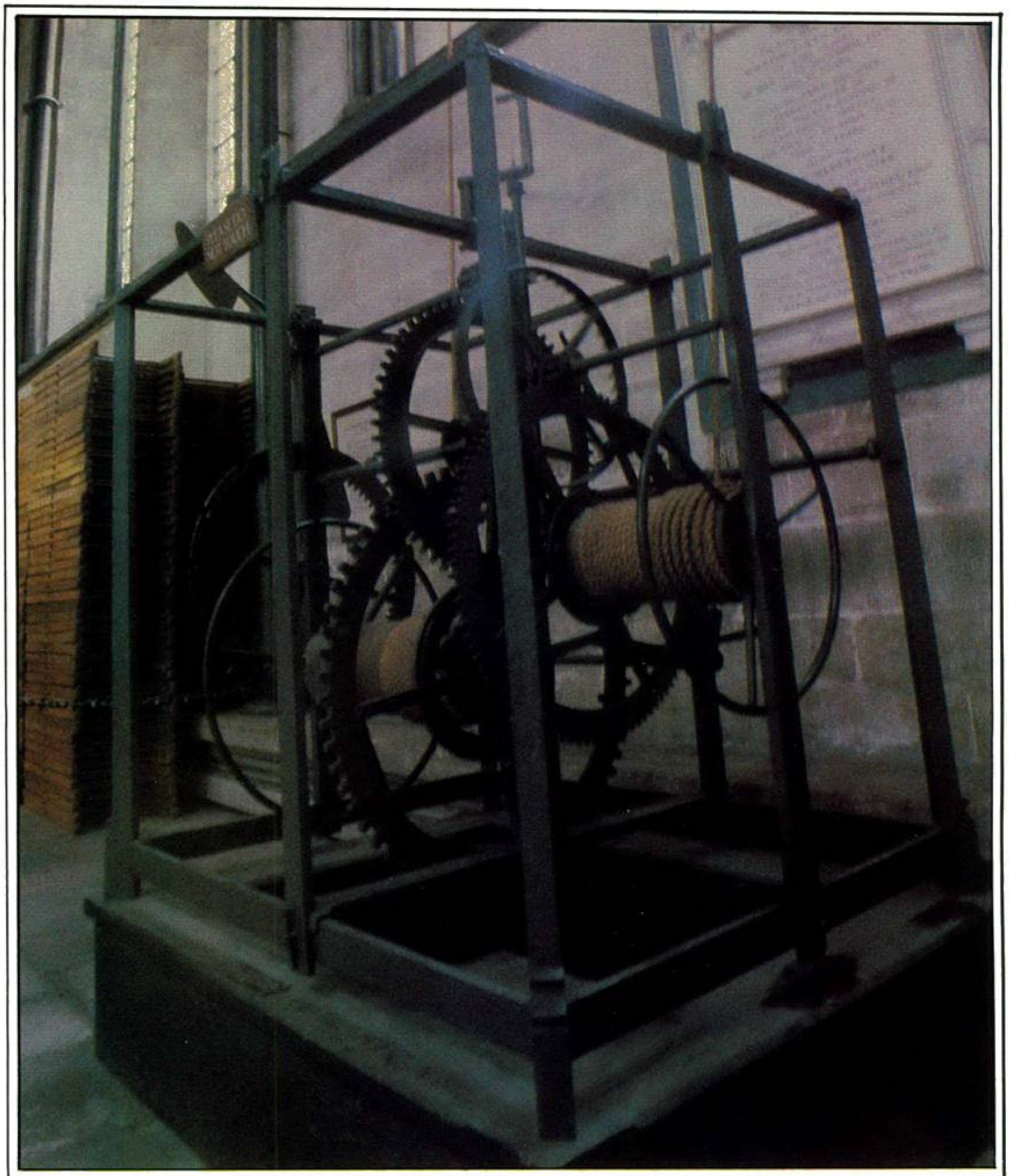


Ghostly Drummers and Zenith Tubes

by Ben Mayer



Half a century before the fortification of Herstmonceux manor, clock makers built the Salisbury Cathedral clock — the oldest now existing in England.

Today the pursuits at Herstmonceux Castle are linked with the stars in heaven, but the history of the ancient mansion where the Royal Greenwich Observatory is located recalls the intricate fabric of English history.

The land surrounding the castle in East Sussex was once occupied by Romans, and a burial site uncovered in 1953 and estimated as first century lies nearby. The manor itself is first mentioned in the *Domesday Survey* of 1086: an entry states that the land was held "of the Count of Eu by Wibert" and that before the Norman conquest, the tenant was a man named Edmer.

Early in the 14th Century the building passed by marriage to John de Fiennes, whose crest sported three gold lions on an azure field. His descendant, Roger, fought at Agincourt with King Henry V.

In 1441 Sir Roger Fiennes received license from the King to "enclose, crenellate and furnish with towers and battlements his manor house at Herstmonceux." Arrowcrosslets and gunports still bear witness to the military past of the establishment. But Royal favor soon gave way to disgrace when a later descendant, Thomas the third Lord Dacre, was executed for the murder of a gamekeeper.

According to legend, the castle is endowed with ghosts, the most unusual being the apparition of a nine-foot tall drummer who was said to walk the gallery in the staircase hall, beating a ghostly tattoo. As late as the twentieth century, one of the last private owners of the estate was "not unduly disturbed at having seen the ghost of Richard Fiennes, Sir Roger's son, on the South bridge near the gate house, more than once."

Since its founding in 1675, observing conditions in Greenwich at the Royal Observatory have deteriorated due to atmospheric and light pollution from London. So, in 1946, the Admiralty announced that Herstmonceux — with its ghosts and its history — was to become the future home of the Observatory. Today, some nine hundred years after William the Conqueror's survey, the property has passed from the Admiralty to the Science Research Council (SRC), which is funded by the British taxpayer.

Since the move to Herstmonceux, Greenwich Mean Time (GMT), or Universal Time (UT) as it is known to astronomers, now dwells approximately fifty miles south of London and precisely 1'21.0758" east of the Greenwich meridian. Corrections for this departure from zero longitude are carefully computed into all data emanating from the new RGO.

Today, the RGO continues as a national observatory and provides accurate timekeeping and navigational almanacs as well as measurements of the positions of the Sun, Moon and planets.

But the first duty of the Science Research Council is to support scientific research in British universities. Thus a prime function of the Observatory is to provide telescopes and astronomical instruments for astronomers from universities and from the Observatory itself.

Though seeing conditions in the south of England are often hampered by poor weather, there are several telescopes of note on the Herstmonceux site. Near the entrance to the complex stands the "equatorial group" which houses six instruments — among them a 36" reflector and a 26" refractor.

But the Observatory's large and modern telescopes are sited where skies are clear and the seeing is suberb. The SRC is now building a new observatory at Las Palmas in the Canary Islands for British astronomers, with telescopes of 1.0, 2.5 and 4.2 meter apertures due to be completed in the next couple of years. One of them, the 100-inch Isaac Newton Telescope, was originally housed in a large dome southeast of the castle at Herstmonceux, but is now being installed at Las Palmas. It should be completed in 1982.

In the historical tradition of the famous Astronomers Royal, notably James Bradley (b. 1693, d. 1762) and George Airy (b. 1801, d. 1892) who pioneered meridian astronomy and established the Greenwich line of zero longitude, a considerable amount of effort is still spent at Herstmonceux in observations and research involving transit circles and the precise measurement of astronomical time. Unlike regular telescopes, which can be aimed at any sector of the sky and can follow the stars as they move across it, a meridian transit telescope can only be pointed along the meridian.

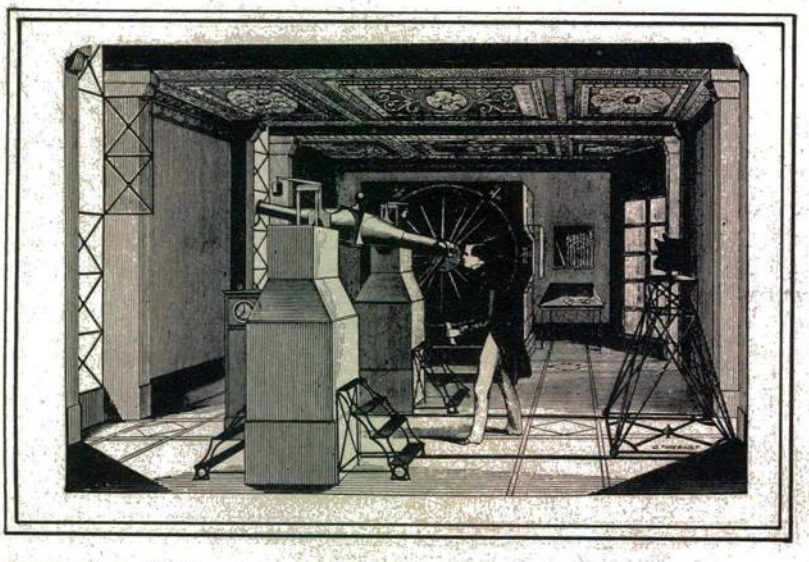
A transit circle pivots with its massive axis supported by two fixed piers east and west of the telescope. The telescope can be trained on any point in an arc extending from north, through north celestial pole, to overhead and on to south — but nowhere else. The shutters in a transit observatory therefore open on both the north and south walls as well as the roof, but there is no rotating dome.

Stars are observed as they pass through (transit) the field of the transit telescope. As each crosses the carefully determined meridian, an astronomer makes two critical measurements: the exact time of transit, and the angle of elevation to which the telescope must be tilted to sight that specific star.

The exact right ascension of the star can be determined from its observed time. The star's declination is computed from its altitude angle. In order for these observations to be meaningful, the observer needs to know the time at which the "first point of Aries" (the celestial zero-point) crosses his meridian, and the altitude of the celestial equator on the meridian.

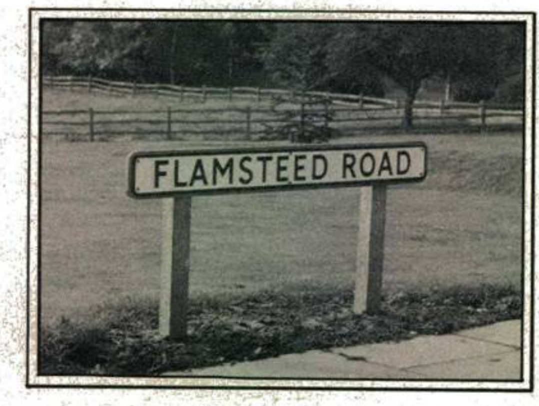
Although all these lines of demarcation are neatly printed on maps and celestial charts, they are visible neither in the heavens nor on Earth and must be found by careful measurement of the Sun as it travels along the ecliptic above and below the equator.

One way of finding the invisible celestial equator draws on the fact that it lies 90° from the celestial poles. The poles are not visible either, but can be located because they are at the centers of the circles traced out by the stars in their apparent rotation.



Left: A meridian telescope at the Paris Observatory.

Below: John Flamsteed is among those honored at Herstmonceux today.



The charting of the celestial sphere for timekeeping purposes — initiated in 1675 at the Royal Observatory during the reign of Charles II — continues today with the Cooke transit circle. Other similar instruments in Washington, D.C. and at Pulkovo Observatory, near Leningrad in the Soviet Union, work with the RGO. Lately the transit work has been supplemented with information collected through radio interferometry combined with the latest in computer technology.

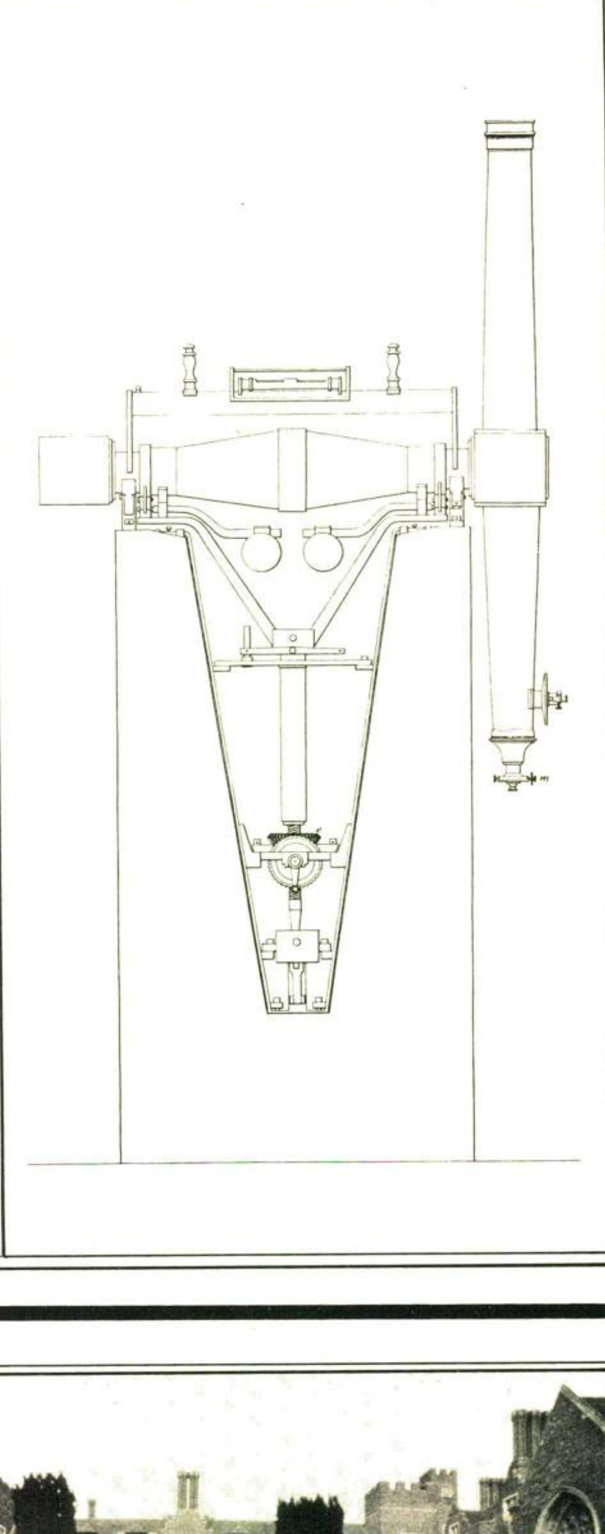
Still, there are several reasons to continue the basic visual studies. Although they originally helped navigators establish longitude at sea — through their inclusion in a nautical almanac published at Greenwich — transit observations have also provided other important data.

Transit information was even used to check Newton's famous law of gravity as it applied to the Moon and the planets. Centuries later, data showed the small individual motions of different stars, giving astronomers vital clues to the distances of stars, and leading to an understanding of stellar evolution — all while showing that the Earth is not the ultimate keeper of time.

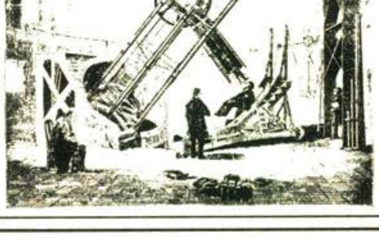
Today, as we begin to navigate in space, the most exacting criteria of accuracy are needed to keep satellites, spacecraft and orbiting laboratories with human crews on course. The old pendulum clocks are long gone — replaced by atomic clocks. Deployed in different parts of the world, their readings are regularly compared through special radio signals.

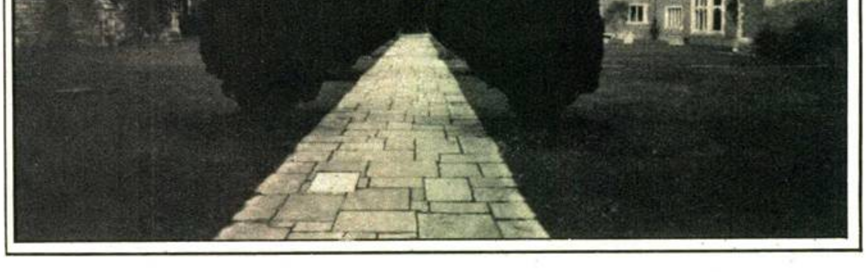
The half dozen atomic clocks in the air-conditioned basement of the Royal Greenwich Observatory keep time to an accuracy of a few thousandths of a millionth of a second per day. Careful comparison with astronomical data has shown that the length of a day fluctuates by about a millisecond during a year, mostly because of the seasonal effects of the Sun on the Earth's atmosphere. The old transit records not only show that the length of the day varied in the past, but that the day is becoming progressively longer, year by year.

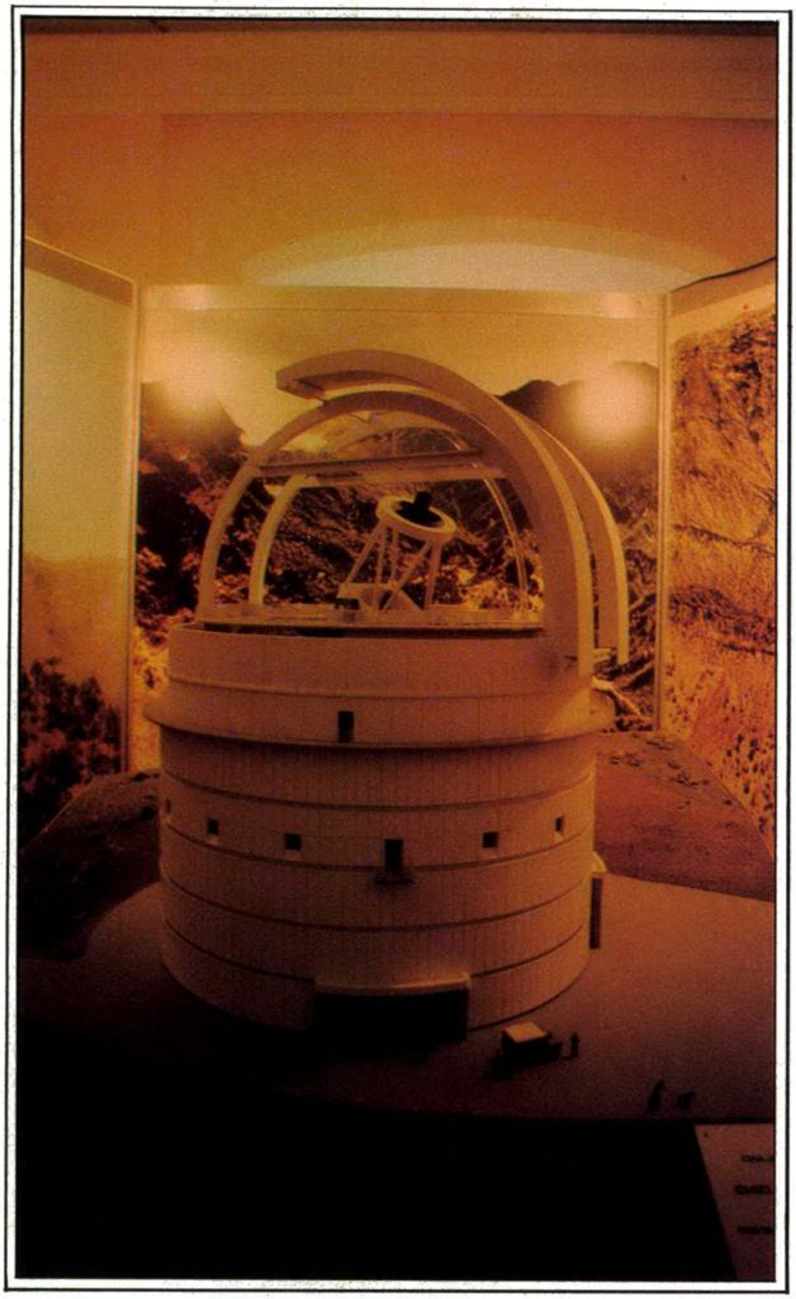
This slowing down of the rotation of the Earth is not small. If an atomic clock had been set in 1680, it



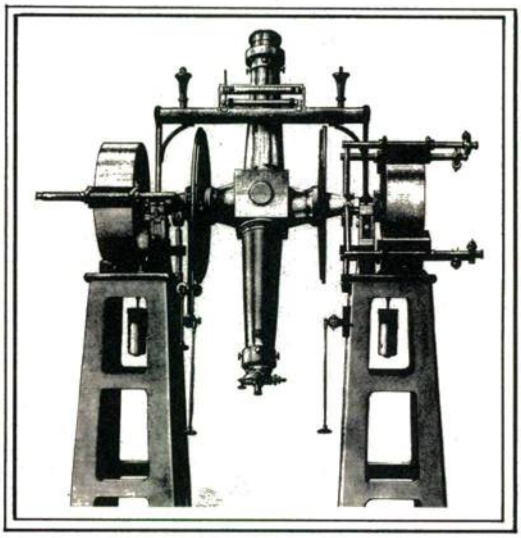
The Great Equatorial was a resident at Greenwich before the RGO moved to Herstmonceux.







Left: A model of the SRC 4.2 meter telescope and dome under construction at Las Palmas in the Canary Islands.
Below: Meridian telescopes are among the most magnificent — and carefully pampered — astronomical instruments.

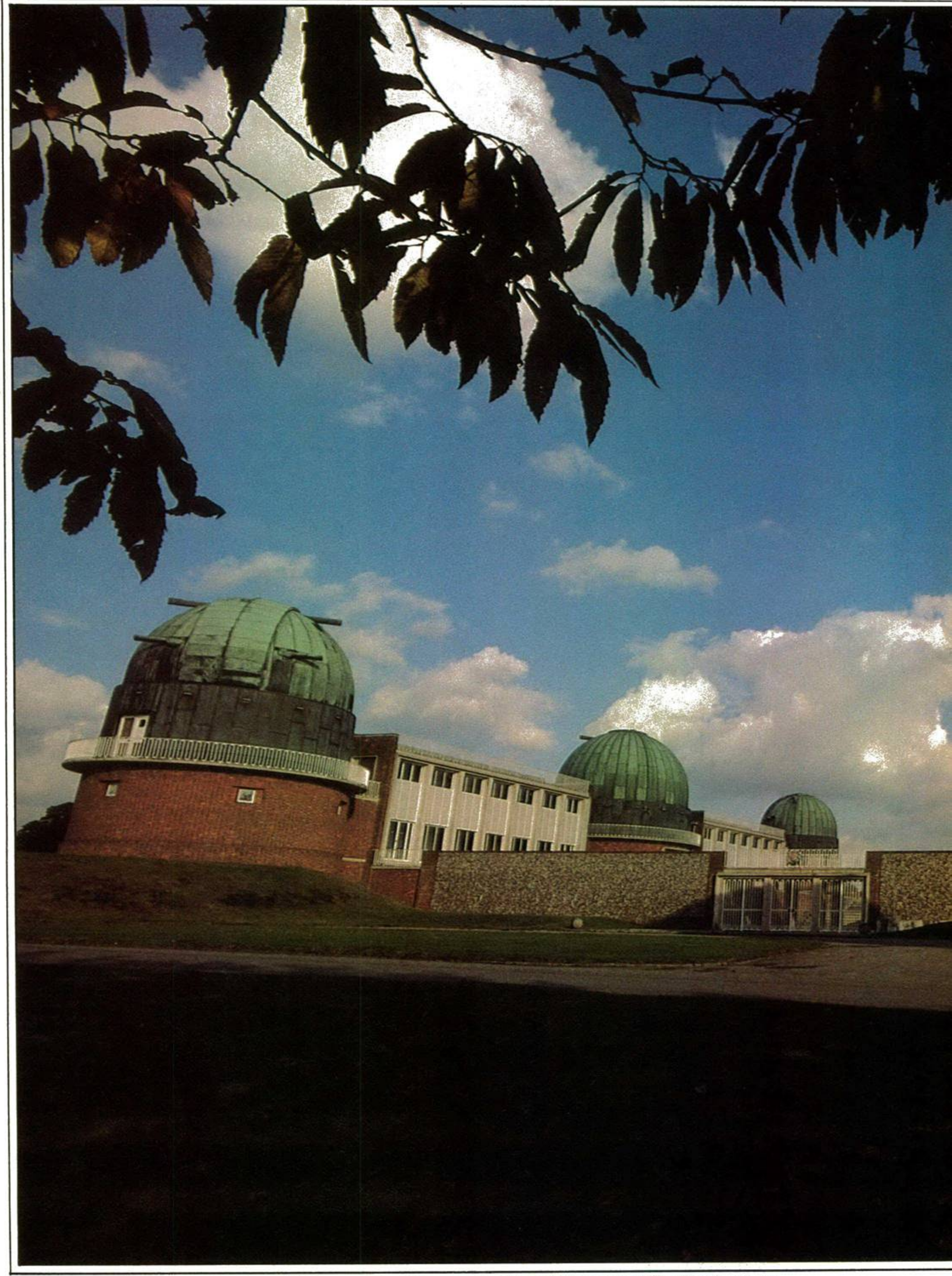


would, by now, be three minutes fast relative to Earth! That is not the fault of the clock — it is Earth's lagging, slowed by the action of the tides raised by the Moon and the Sun.

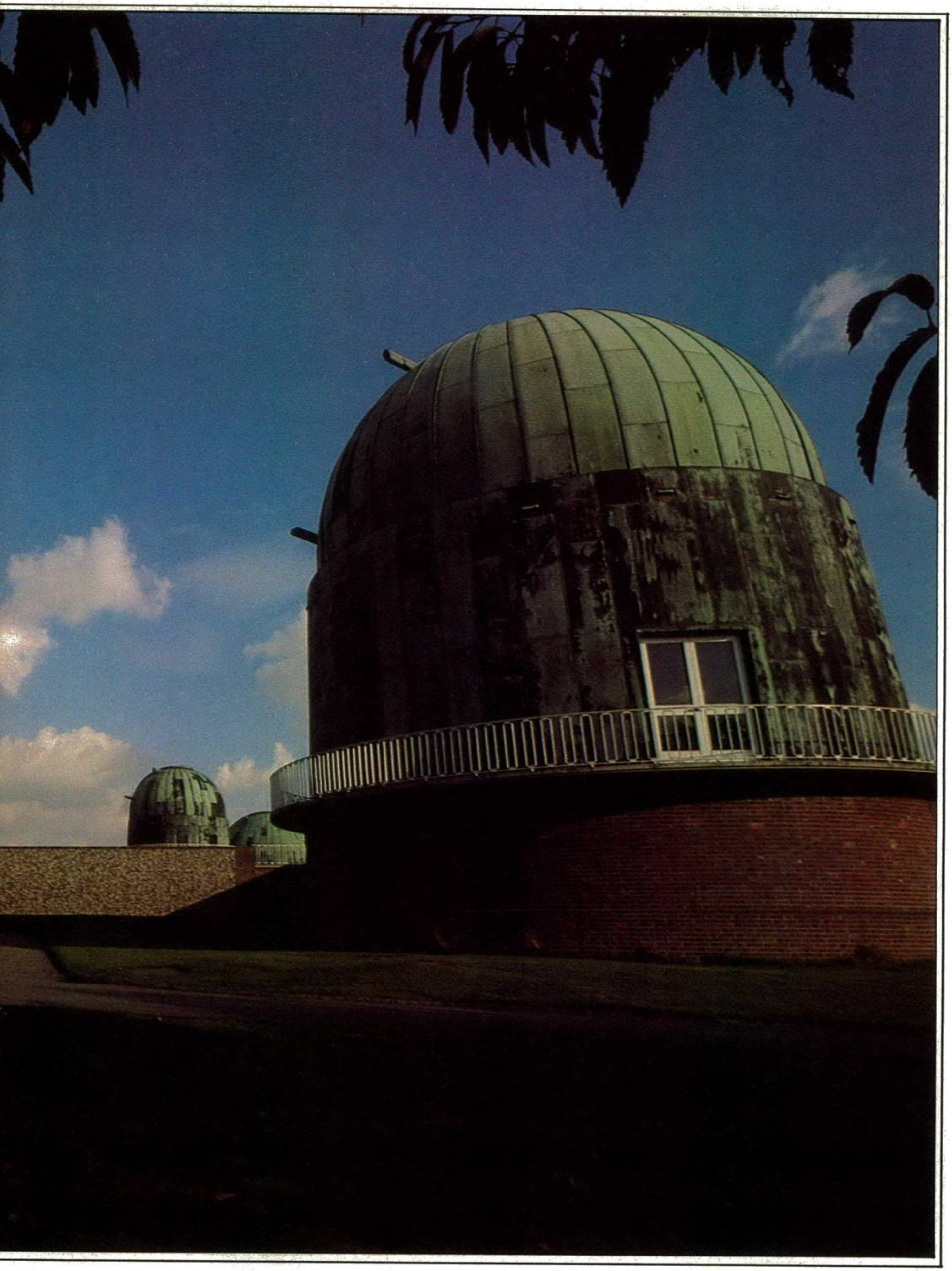
The Greenwich Observatory is responsible for the establishment of the National Time Service in the United Kingdom. It is a major contributor to the International Time Scales determined by the Bureau International de l'Heure (international time office) in Paris. But civil use such as lighting up times, railway and airport timetables, or commercial broadcast timing hardly seem critical when weighed against the accuracy of one thousandth of a second or better in science, where researchers deal with the orientation of the Earth in relation to a star for radio astronomy or deep-space research. Some technologies require time-synchronization of still greater accuracy, to microseconds or less. For this, a uniform and precise time scale is needed.

Equipped with astronomical time-keeping instruments more precise than transit circles, and assisted by uniform atomic clocks, the RGO works to maintain a precise time based on the modern definition of a second as "the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom."

Since stellar observations are convenient and give far greater accuracy than observation of the Sun, the timekeeping astronomers mark the moment of star transit with a Photographic Zenith Tube (PZT). As the name suggests, this is a telescope which permanently points toward the zenith. Light from a carefully chosen overhead star passes down through an objective lens and is then reflected from a pool of mercury and recorded on a photographic plate



Despite the attractions of high mountain skies, many working telescopes are still at Herstmonceux.



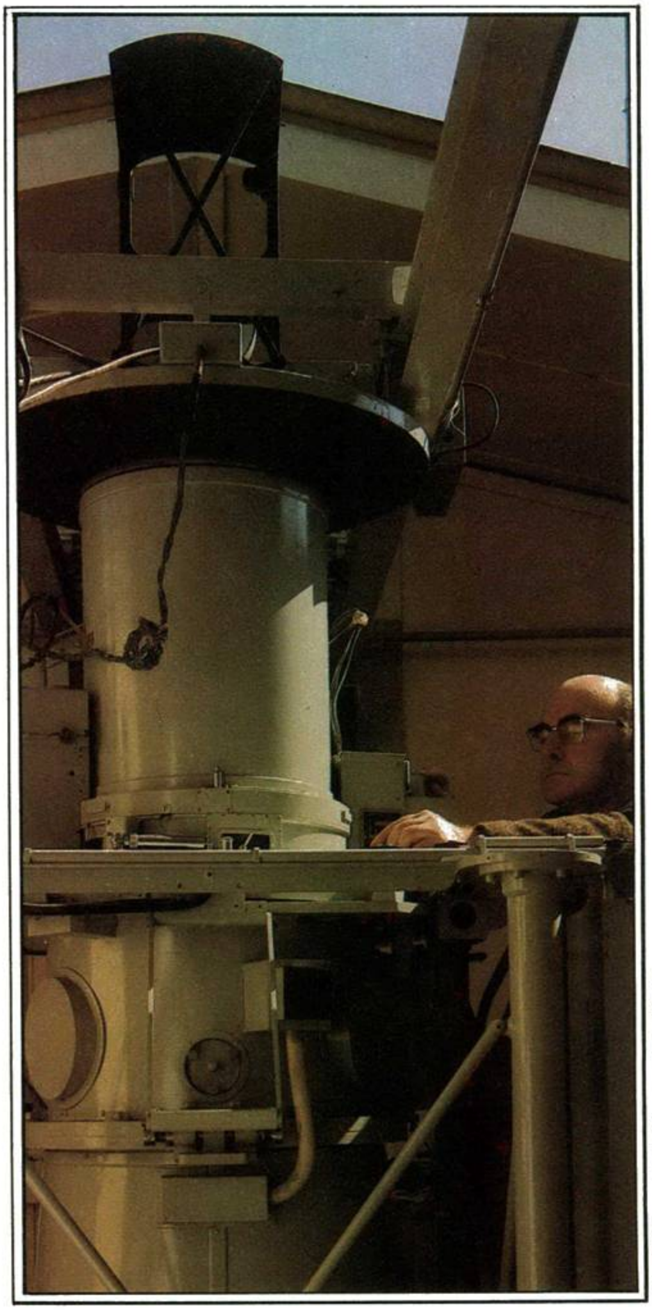
suspended centrally just under the objective lens. To obtain point images of the stars and to compensate for the revolution of the Earth, the plate carriage inside the telescope is driven by a motor during exposure in the same direction as the stellar image moves. The time of each of the exposures is controlled by the opening and closing of a shutter under the control of a precise clock.

The result of a fully-reduced PZT observation is the exact time of transit of a star near the zenith. Because atmospheric refraction effects are zero at the zenith, the measurement is better than a transit observation. Also, because the tube of a meridian transit may bend a little from star to star, and because the PZT cannot flex, instrumental errors are smaller. Accuracy is further enhanced by obtaining four images of each star, with the plate in the instrument rotated 180° between the critically timed exposures. Even the effects of tides in the mercury pool serving as a mirror have been deduced — with an accuracy of 0.0015 arc-second — and have been taken into account.

Thus GMT is based on the rotation of the Earth. The time signals broadcast by the BBC are based on a uniform atomic time. As Earth's varies, the two timescales may shift and wander. The PZT finds the difference between them. Through the insertion of "leap seconds," preferably at the end of December or June, these critical time scales are brought into accord.

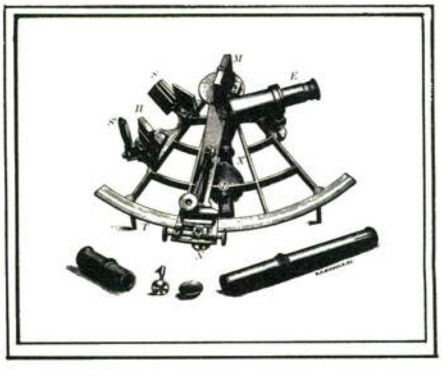
The Royal Greenwich Observatory collaborates closely with the Bureau International de l'Heure. Continuously provided with information by national observatories from around the world, the BIH, in turn, produces both the definitive Universal Time and the international atomic time scale.

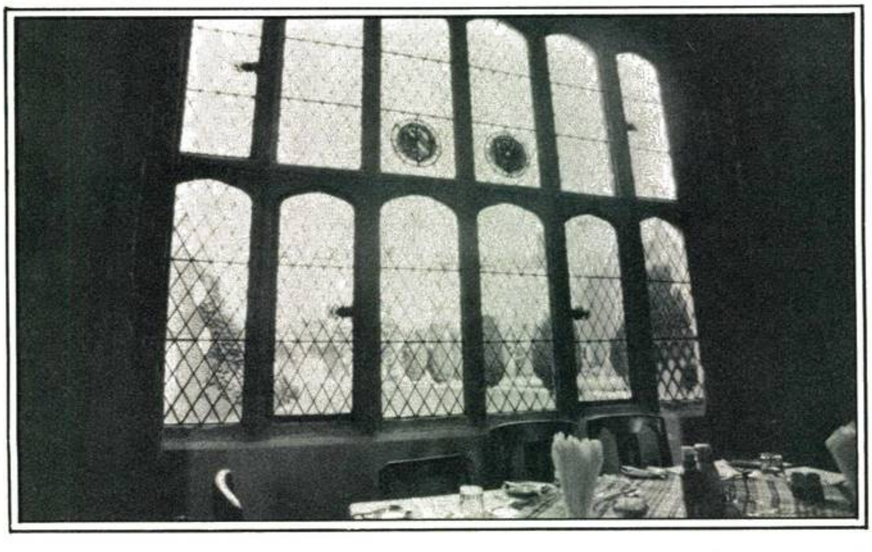
The collaboration between selected observatories with PZT capabilities and agencies such as the Jet Propulsion Laboratory in Pasadena is organized by the Bureau International de l'Heure. JPL has acknowledged that the successful navigation of the Mariner 9 probe to Mars and the Mariner 10 to Venus and Mercury was greatly aided by the PZT observations communicated daily over critical periods of the flight by the BIH.

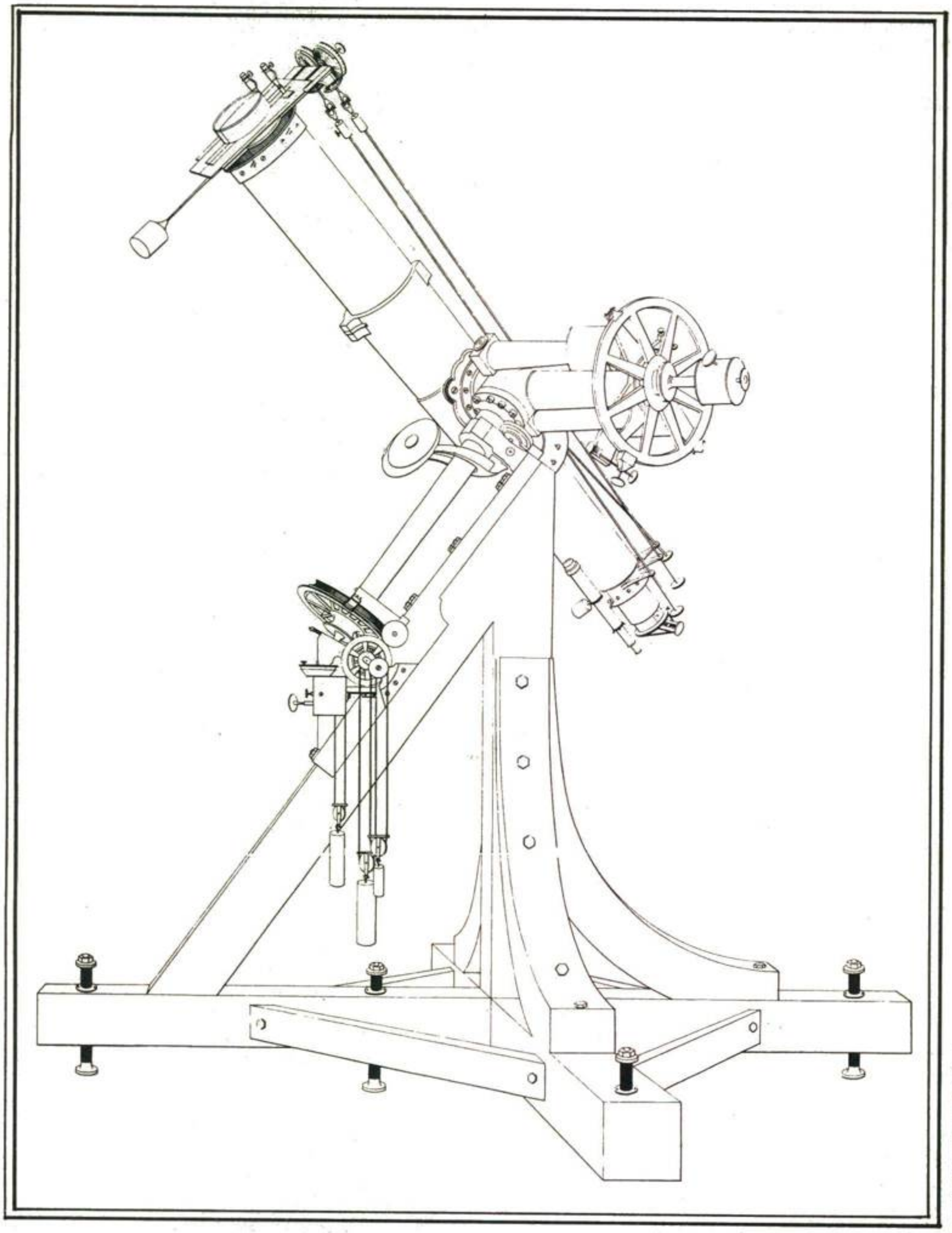


Royal Greenwich Observatory Photo

The accuracy of a modern PZT exceeds by thousands of times that of its predecessor, the simple mariner's sextant.







Around the world, two centuries of astronomers have devoted their lives to precision measurements of stellar positions and time — the basis of modern astronomy. Shown is the 6" Repsold heliometer of Konigsberg Observatory, then in Germany.

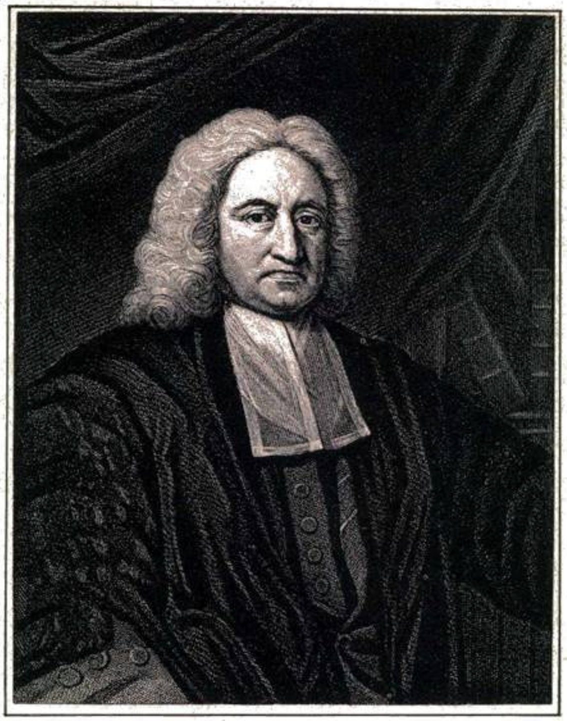
But the leap from timekeeping in the space age to timekeeping 600 years ago is not long — whether measured by geographical distance or accuracy. Not far from East Sussex is the 14th century clock at Salisbury cathedral. This ancient mechanism is at work — still functioning — six hundred years after its construction in 1386. The medieval clock at Salisbury pre-dates by half a century the fortification of Herstmonceux manor, and is the oldest existing clock in England — or possibly in the world.

The famous timepiece was built of hardwrought iron. It was originally controlled by a verge escapement and a foliot balance, but later improved by a pendulum escapement. Modern horology owes much to the fundamental concepts developed by artisans of long ago. The Salisbury clock was probably the work of one or more horologers who came to England from Delft in the Low Countries, at the invitation of King Edward III.

As you view the 20th century marvels of accuracy at the Royal Greenwich Observatory — where even today stars are still observed as they transit — and as you hear the soul-stirring chimes of the Bishop's bell in Salisbury cathedral, you cannot help but feel the summons of nearby Stonehenge where monoliths beckon to you and to the time of transit of the midsummer Sun.

The writer in indebted to Nathy O'Hora, Senior Scientific Officer and head of the PZT section of the Time Department of the RGO, who took time out from a busy schedule to share the beauty and history of Herstmonceux with the readers of ASTRONOMY.

Ben Mayer is a Los Angeles amateur astronomer who has followed the eclipsed Sun — and astronomical history — around the globe. He wrote on the Royal Greenwich Observatory in "Transits and Timeballs," December 1980. Photos by Ben Mayer.



MR. HALLEY'S HAIRY STAR

Comets are the fuzzy tramps of the solar system. In they sweep, past the outer planets, growing bright and glorious for a time in the warmth of the Sun, only to return once more to their cold dark home, a light-month or more from the solar hearth. Their shows are always unexpected; we enjoy them and save up stories of spectacular apparitions to tell to our grandchildren.

But earlier ages saw no delight at all in comets. Far from being pleasant spectacles, they were demons or evil omens, foretelling disaster and riot in veiled, oblique ways. When a comet appeared, everyone from the king to the serf conferred anxiously with astronomers and astrologers about what it portended and how best to guard against its ill effects.

Our name for them goes back to the Greek kometes *meaning hairy star — a fine naked-eye description. But the ancients weren't sure what a comet was. Demokritos believed they occurred when two planets came too close together, and Aristotle thought they were phenomena given birth in the Earth's atmosphere. Later, in Roman times, Seneca noted that since comets weren't affected by wind or weather, they could hardly be atmospheric. But the beliefs of Aristotle prevailed. It wasn't until 1577, when Tycho Brahe proved that the bright comet of that year lay far beyond the Moon, that the Aristotelian view begin to lose its hold. Even so, it took about a century of observations and heated debate before cometary astronomy really began.*

From the direction of southern Gemini, between the orbits of Saturn and Uranus, Halley's Comet is coming back. Perhaps it's not surprising how long it took for the realization to sink in that one somet kept coming back every 76 years. When a bright comet appeared in 1682, astronomers observed it and plotted its course, but few gave it any special thought. However, this comet planted a seed in the mind of 26-year-old Edmond Halley — a seed that grew as the years went by.

Twenty-one years later, upon accepting the chair of geometry at Oxford University in 1703, Halley began work on a book, *Synopsis of Cometary Astronomy*. Using the celestial mechanics just developed by his friend Isaac Newton, Halley calculated parabolic (open-ended) orbits for 24 comets seen between 1337 and 1698. He was immediately struck by the orbital similarities for the comets observed in 1531, 1607, and 1682.

Faithfully reappearing every 76 years, Halley's Comet is the most famous in history. Since its earliest recorded apparition in 240 B.C., it has awed, terrified, and delighted mankind — from ancient to modern. This photograph, taken June 6, 1910, shows part of the comet's tail (above and to the left of its bright head) drifting away. At this point, the comet had passed its closest approach to the Sun and was outbound again. Photograph from Yerkes Observatory.

At the time, astronomical opinion held that comets were interstellar wanderers and not members of the solar system. But the similarity of orbits was too strong a coincidence for Halley, especially since there was a regular interval — about 76 years — between appearances. Following this clue, Halley applied Newton's formulas for calculating ellipses (the shape of a closed orbit) and confirmed that the comet was a member of the Sun's family. It circled the Sun as planets do, but in a long, slender orbit unlike any of the planets. Halley used his calculations to predict a 1758 return for this comet — one that he had little hope of seeing.

Soon after Halley's death in 1742, three French astronomers independently took up where he left off and computed the comet's path in greater detail. Their calculations provided astronomers with a list of dates and positions to aid their searches for the comet in 1758.

One of the first to begin regular sweeps was the great French comet hunter Charles Messier. He succeeded on January 21, 1759, only to learn that the German amateur astronomer Johann Palitzsch had spotted it on December 25, 1758. Calculations from the new observations revealed that the predicted date of *perihelion* — closest approach to the Sun — had been in error by only 32 days.

After the 1759 apparition of the comet (now named in Halley's honor), an unofficial contest began as astronomers worked on predictions for the 1835 return. The target was an accurate prediction for the perihelion date and the gravitational effects of the six known planets were considered. But the labor was in vain — William Herschel's discovery of the planet Uranus on March 13, 1781 compelled them to start all over again! After allowing for Uranus' gravitational effects, new predictions followed: November 4, 1835 (Damoiseau), November 13 (Pontecoulant), and November 26 (Rosenberger).

Decades passed — and two new generations of astronomers followed. As the predicted dates approached, anticipation built up. Searches began as early as December 1834, but again the earliest sweeps were unsuccessful. The first glimpse of the comet was on August 6, 1835, by Father M. Dumouchel of Rome. The perihelion date turned out to be November 16 — three days after that predicted by Pontecoulant.

After the 1835 apparition, the computations moved in a new direction — backward. Translations of Chinese comet catalogs were coming to light and several astronomers and mathematicians compared the dates of ancient comet sightings with "predicted" past appearances of Halley's Comet. If future orbit predictions were ever to become accurate, they reasoned, the best way to check was to calculate earlier approaches — 76 years, after all, is too long to wait.

Actually, tracing the comet backward began with Edmond Halley himself. He had identified the comet of 1456 — an impressive object which struck terror in the hearts of the Turkish army during the battle of Belgrade — as a previous return. Another identification was made by the French mathematician J. K. Burckhardt in the late 1700s, when he established that a comet widely observed in China and Europe during 989 was a past appearance.

After the 1835 return, P. A. F. Laugier, an astronomer at the Paris Observatory, succeeded in pinning down three ancient sightings — 451, 760 and 1378. Another observer, John Russell Hind, was only 12 years old in 1835, but his strong interest later helped him undertake the most elaborate search for previous appearances of the comet.

Hind concentrated on the Chinese annals and came up with fifteen probable apparitions. He based them on the comet's recorded appearance and its path across the sky. Hind was able to push the list back to 12 B.C., when the citizens of Rome were terrified by the comet that appeared to be suspended directly over their city.

Hind's list was considered complete until the beginning of the 20th century, when Philip Cowell and A.C.D. Crommelin of the Royal Greenwich Observatory began to recalculate the comet's orbit for the forthcoming 1910 appearance.

In an age without electronic computers (remember, "computers" were people who sat at desks and computed — with pencil and paper), Cowell and Crommelin took on the laborious task of calculating the orbit of each of the comet's past apparitions. They discovered that three of Hind's identifications were incorrect, but confirmed the other twelve and extended the comet's history to 240 B.C. The past sightings helped confirm the computations, and the date of next perihelion was predicted to be April 16, 1910.

As before, the desire to be the first to see Comet Halley again started observers looking long before it could be detected. Searches began in the winter of 1908/9 and, for the first time, astronomers used photography. The initial search plates were taken on December 22, 1908 at Yerkes Observatory, but the recovery photo was by Max Wolf of Heidelberg, who spotted the small diffuse image of the comet on a plate exposed September 11, 1909.

Cowell and Crommelin's orbit was more precise than any previous — they had figured in perturbations from the planet Neptune, discovered in 1846. But despite their great care, observations showed the calculations were still three days in error.

A margin of error of three days in 27,180 doesn't sound like much and, at the time, the discrepancy did not get too much attention. Also, the returns of virtually all periodic comets were off by a few days, so the problem wasn't confined to Comet Halley alone. Astronomers knew that something was affecting cometary orbital motions, but no one knew just what.

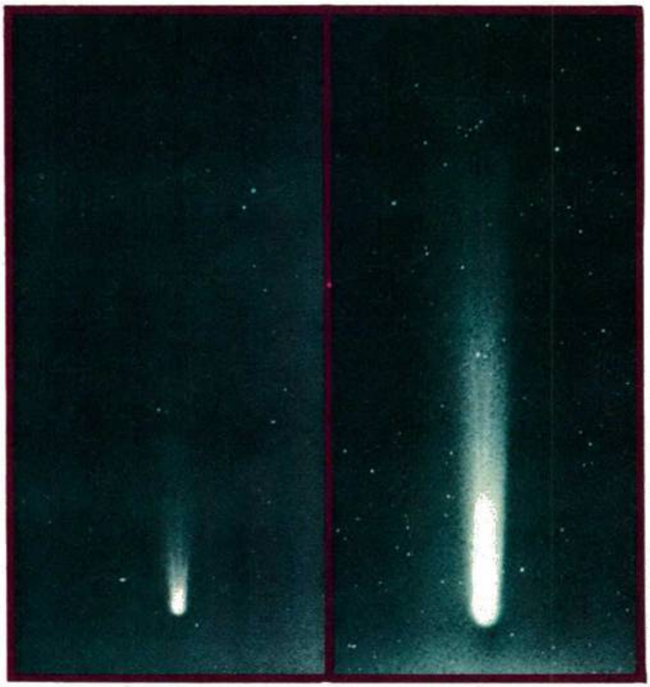
Time passed and several ingenious theories were proposed, but in the end the most popular was that of "nongravitational" forces — jets of some sort emanating from the nucleus. Simple physics showed that a nuclear jet could alter a comet's motion and bring about a change in the orbit.

Although astronomer Friedrich Bessel had suggested nongravitational forces as long ago as 1836, it wasn't until the mid-1960s that scientists knew enough about the physical nature of comets to work out a theory.

Even now, the non-gravitational forces acting on comets are still surrounded by debate. Part of the difficulty comes from poor data: although Halley's Comet has been observed many times, a precise orbit exists for only the 1910 appearance. After a thorough investigation, astronomer Pedro Zadunaisky found that Comet Halley's positions were best fitted by two slightly different orbits — one pre-perihelion, the other post-perhelion. Zadunaisky proposed the varying orbits were caused by a break in the comet's motion around the date of perihelion.

Another astronomer, Zdenek Sekanina, examined the telescopic observations of 1910 for evidence of changes around perihelion. What he found convinced him that an explosive event had

The gaseous tail of Comet Halley can markedly change its appearance — even in a 24-hour period. The photograph at near right was made on June 6, 1910, the one at far right a day later. (Compare with the photograph on page 16.) During the interval, the separated part of the tail has blown farther away from the nucleus while the nucleus itself has retreated. Background stars appear as short streaks because the camera tracked on the comet. Lick Observatory Photograph.



April 26, 1910 **April 30**

Mt. Wilson & Palomar Observatories photographs

occurred — just the thing to change an orbit. Rapid variations in brightness, secondary nuclei, and strange formations within the comet's tail and coma had all been reported by observers. The "two orbit" hypothesis looked pretty good.

Still, the matter was far from settled. In 1966 Joseph Brady and Edna Carpenter computed and published a new orbit for Halley's Comet. They claimed that two orbits were unnecessary and that the 1910 positions were, in fact, adequately represented by one orbit. Five years later they published a refined orbit for the 1986 return and traced the comet's motion back to 295 A.D. They found that the differences between the calculated path and the actual observed path changed in a cyclical way roughly every 500 years. Brady credited this to gravitational attraction from an unknown planet beyond the orbit of Pluto. Although astronomers searched diligently, no tenth planet was found. Naturally, this hasn't helped settle the one orbit *vs.* two orbit problem, so the whole matter will probably wait until after 1986.

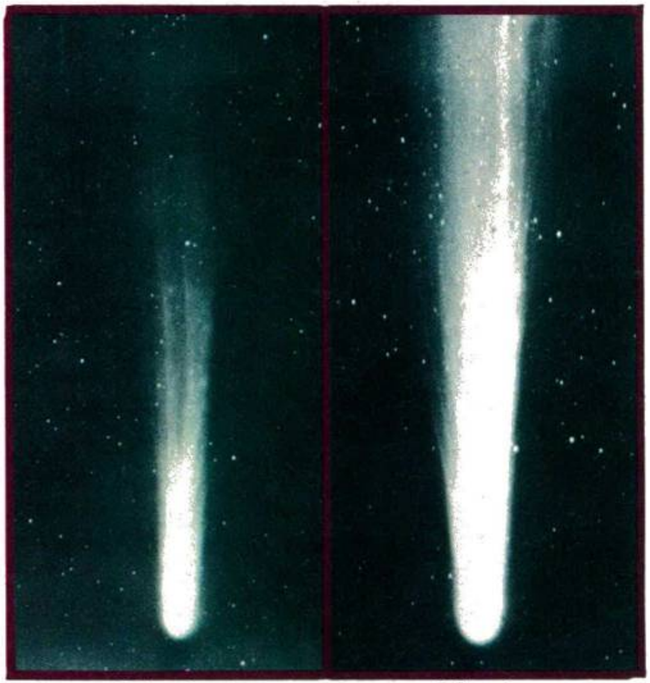
But orbital motion is just one aspect that interests scientists. A lot of attention will center on the comet's physical composition: chemical content, structure, and brightness. Every comet loses material at each perihelion passage and thus becomes slightly dimmer at each apparition. Halley's is no exception. From Chinese descriptions, astronomers have found that at each return, the comet has become fainter and its period of visibility shorter.

Of course, from Earth the most impressive part of any comet is its tail. During past apparitions the tail of Halley's Comet has averaged 15° to 20° in length, but a record length — over 100° — occurred during very close approaches to Earth in 374 and 837. The tail, however, is really quite tenuous.

Another cometary feature, the nucleus, is the most massive and the most important part. It controls every other aspect of a comet's appearance; the brightness of the tail, for example, depends on the amount of material shed by the nucleus, since the tail is just nuclear material — both gas and dust — blown off into space.

Yet the nucleus is quite small — only a few kilometers across — and our views of it are blurred and indistinct because of the shroud of gas that envelops it. The nucleus will be the most closely studied part of the comet on its next return — and all the more because of peculiar activities noted in 1835 and 1910.

In 1835 Bessel noted small "jets" protruding from the nucleus; they were observed again in 1910. The jets squirt gas and dust, "evaporated" by warm sunlight from the nucleus, into a gaseous envelope, the *coma,* which surrounds the nucleus. Under the pressure of solar radiation and particles, coma material streams out to become the tail.



May 3 **May 6**

Why the jets appeared so distinct is still unknown, but clearly they represented vigorous activity — activity which has suggested that Halley's Comet is on the verge of breaking up.

Although jet-like formations have been seen in a few other 20th century comets that didn't break up, the "imminent-disruption" model has evidence to support it. On many occasions between April 16 and June 4, 1910, astronomers noted that Halley had two nuclei instead of one. The secondary nuclei were only temporary features lasting no more than a day each, but this soon changed.

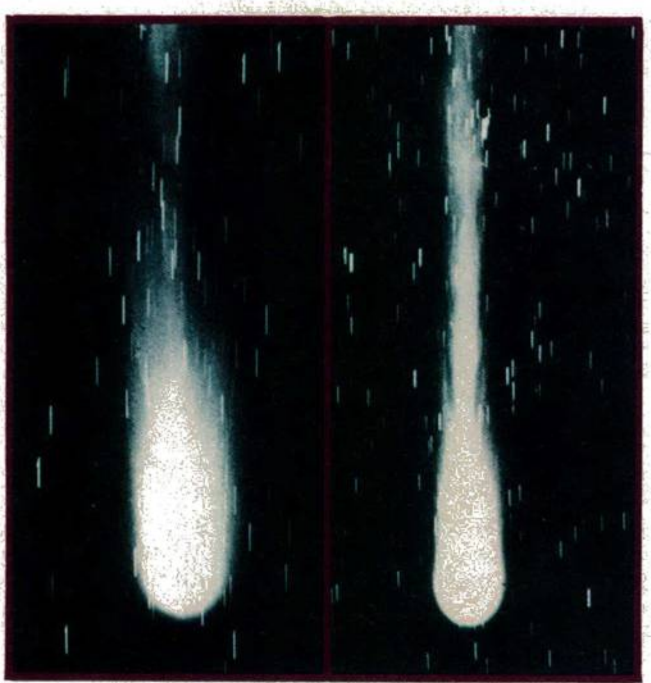
On May 31, observers detected a brilliant projection from the nucleus. According to some, the projection had not appeared in photos taken the day before. The projection faded quickly the next day. By June 2, the comet seemed to have split into two nebulosities, each with its own nucleus. Astronomers at Johannesburg photographed three nuclei on the same date. On June 4, there was no trace of the second nucleus. However, the primary nucleus was accompanied by four smaller condensations, moving rapidly away from the primary. After this, no more secondary nuclei were reported.

But Halley's secondary nuclei don't seem to last long and, to judge by their faint light, are much smaller than the primary nucleus. These secondary nuclei are probably not large parts of the nucleus, but rather small pieces of its icy surface — broken off much as chips crack off from an ice cube dropped into warm water. Secondary nuclei with small masses wouldn't last long in the fierce radiation of the Sun.

Comet nuclei are basically dirty snowballs, so they release dust as their ices melt in the Sun's heat. The dust, blown off to form the coma and tail, is lost to the comet. However, the larger dust grains continue to follow their parent comet's orbit. The longer a comet travels in a particular orbit, the more evenly distributed the dust becomes. In most cases, this dust isn't noticeable, but when a comet orbit intersects that of the Earth, some of these pieces streak into the atmosphere and create a meteor shower.

Halley's Comet is special because it produces two meteor showers each year: the Orionids around October 20 and the Eta Aquarids around May 3. The Orionids occur when the Earth intersects the inbound leg of the comet's dusty orbital track, and the Eta Aquarids occur when the Earth passes through the outbound leg.

The observational history of these showers, like that of the comet itself, appears in Chinese records. The earliest recorded Orionids were in 585; the first Eta Aquarids in 401. Since the comet is considerably older, it's unlikely these showers suddenly appeared in these years. Rather, scanty records prior to 500 A.D. or perhaps a slight shift in the orbit are responsible for our shortage of information.



May 23 **May 28**

The meteors following along in Halley's orbit may or may not be evenly distributed; several showers once believed uniform have quickened their activity in years when their parent comets returned. For example, the Perseids' normal rate of 60 meteors per hour jumped to more than 150 in 1862 when its parent comet, Swift-Tuttle, returned. This comet is due back in 1982, and the number of Perseids have been increasing dramatically in the last year or two — so a repeat performance appears to be on the way

Both the Orionids and the Eta Aquarids possess annual rates of 30 meteors per hour. We'll have to wait until 1986 to see if these showers follow the trend (the 1910 observations were inconclusive), but the prospects look at least half good. In 1986 the Eta Aquarids will occur less than 45 days after the comet has passed where its orbit intersects Earth's — a strong shower may result. On the other hand, the Orionids appear to be left out: the 1985 shower occurs 73 days before the comet passes the intersection point and the 1986 shower comes 10 months afterwards.

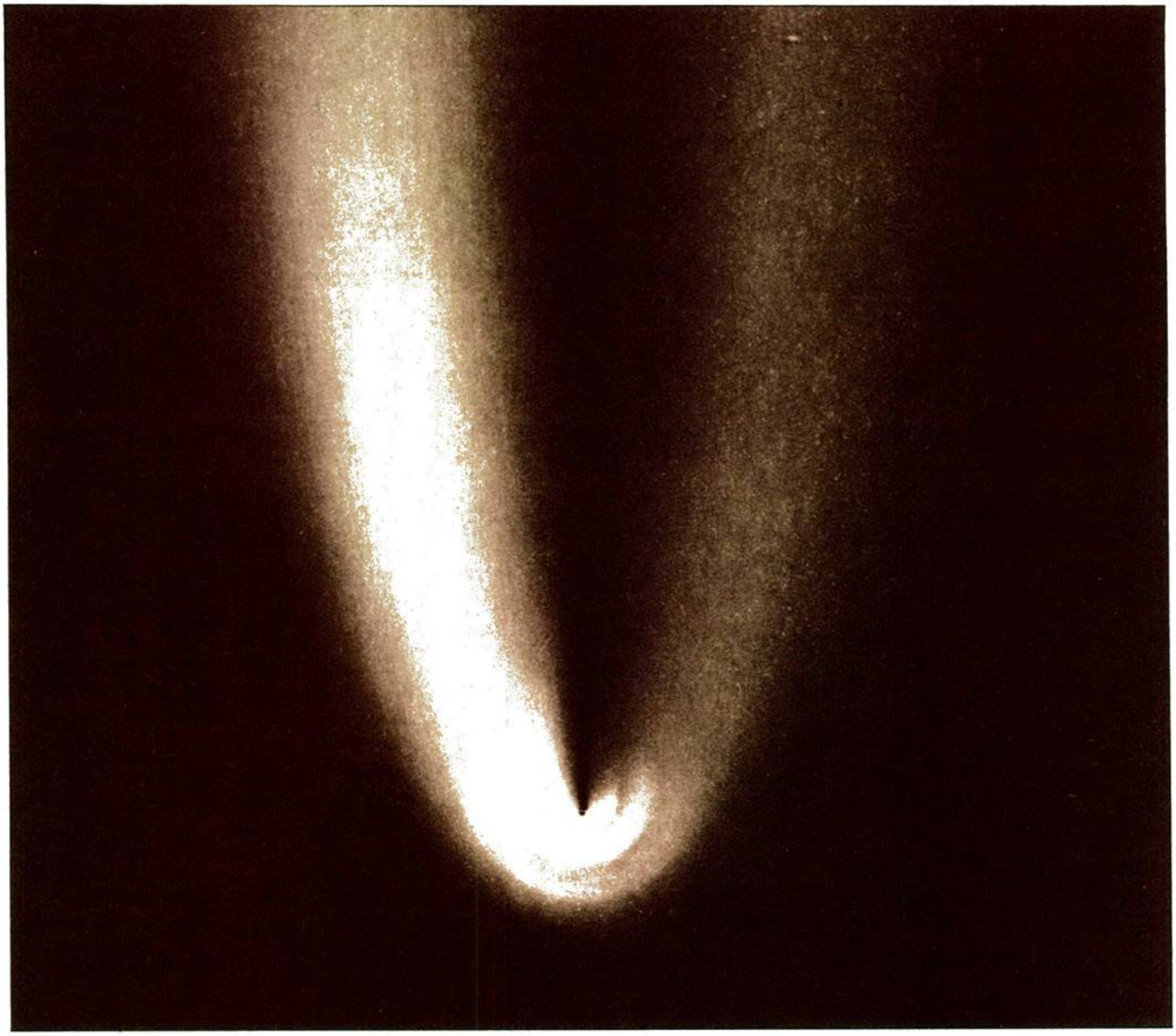
Present calculations predict that Comet Halley will be recovered around October or November of 1984 as a very faint, diffuse smudge on photographs taken through the world's largest telescopes. Backyard astronomers will have to wait another year before the comet brightens sufficiently to be seen in their telescopes.

By late November 1985, the comet will be at opposition in Taurus and, at a magnitude slightly more than 8, should be visible to anyone with a pair of binoculars. After November 26, the Earth-to-comet distance will begin to increase as we move around toward the other side of the Sun. But the comet will brighten as it nears the Sun and by late December will be visible to the naked eye.

December 1985 also marks when the comet begins to move south in the sky. Though it will continue to brighten as it approaches perihelion on February 9, Halley's decreasing elevation will prevent it from impressing observers in the northern hemisphere. The southerly motion continues after perihelion and — when the comet has its second closest approach to the Earth on April 10, 1986 — it will be at the southernmost point of its orbit. Southern hemisphere observers will be treated grandly: a spectacular tail will stretch across the sky.

Astronomer Brian Marsden estimates that, in 1986, Halley's tail will be 20° to 40° long. Unfortunately, when this occurs, the comet will be so far south that little of it will be seen from the mid-

June 3 **June 9**



Photography has greatly enhanced the study of comets, but the necessary long exposures usually overexpose details in the nucleus and wash them out. Visual observation can sometimes reveal cometary features that are hidden to a camera. In this drawing of Donati's Comet — made September 29, 1858 — we see shell-like structures in the gassy coma that surrounds the obscured nucleus. Photograph supplied by Yerkes Observatory.

northern latitudes. Northern observers will have to settle for a 5° tail when the comet again becomes visible to them in early May. By then, the comet will have risen out of the south and will be in the evening sky in Leo. Its brightness will be far below what it was when seen last in March, but at magnitude 7, it should then be an easy target with binoculars.

Comet Halley will continue to fade throughout May and June as it remains nearly stationary in Sextans, and backyard astronomers will probably get their last views of it — at magnitude 12 and fainter — shortly before it disappears into the evening twilight in early July.

Professional astronomers, using much larger instruments, will probably recover the comet as it exits the Sun's glare in late 1986 and will follow it during the first half of 1987. It's even possible the comet will be photographed again at its 1987-88 opposition — 740 million miles from the Sun. Soon thereafter, Halley will leave us until 2061. Then a new generation of astronomers will pick up the inbound sweep of the comet that will probably be the astronomical event of their lifetime.

A Mission to Comet Halley?

As we go to press, the fate of the on-again/off-again American mission to Comet Halley remains uncertain. NASA is considering two possibilities: JPL's Halley Intercept Mission (HIM), and a spin-stabilized probe that would use hardware left over from the development of Voyager and cost less than half as much as HIM.

For background details, see ASTRONOMY, February 1980, p. 16 and 26; May 1980, p. 26; March 1981, p. 59; July 1981, p. 24 and 56.

Gary Kronk is an amateur astronomer with a keen interest in comets. He is working on a book that describes the physical characteristics of past comets and their varying appearances at different apparitions.

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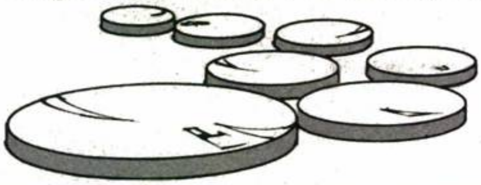

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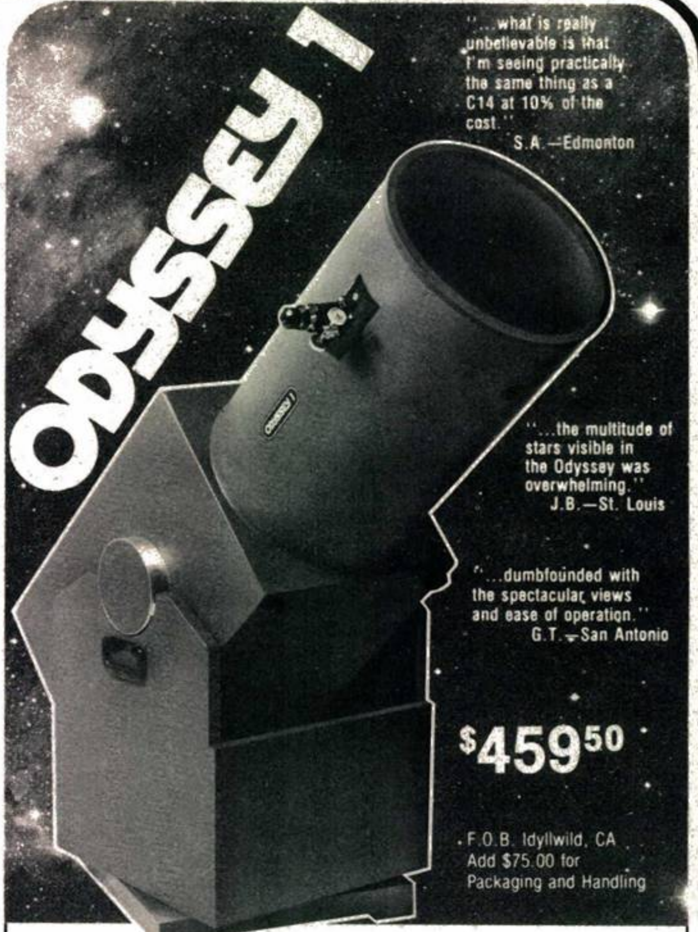

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ASTRONOMY FORUM

The Unslandering of Sloppy Pierre

It's odd that an unfortunate 18th century astronomer should remind me of an early 20th century baseball player who spent his later years smashing radios. Citing his name would merely compound the injustice already done the player; it's enough to say that his creditable career with a top team has been forgotten because, in an ordinary mid-season game (1908), he was on first base when a runner ahead of him was singled home for the apparent winning run — and our tragic hero followed what had been custom up to then and turned for the dugout, neglecting to touch second base. The Chicago Cub second baseman (who knew that, technically, a forced third out negates all runs on that play) grabbed the ball and touched second base. Months later, the league championship was decided by a one-game margin, and the play became baseball legend. Decades later, a broadcast re-telling of the tale within his earshot would drive the wretched ex-Giant to toss the offending radio into left field — or so the legend goes. And the accuracy of legend is what we are about to examine.

Just as every baseball buff before 1950 knew all about the blunder that cost New York a pennant, so every astronomer today knows about Sloppy Pierre, who achieved a dubious immortality as the astronomer whose untidy data recording cost him the discovery of a lifetime: the giant planet Uranus. Indeed, not many modern astronomers could tell you *anything else* about Pierre C. Lemonnier (1715-1799) of Paris, who was in fact an extremely learned and active astronomer in 18th century France, who helped improve the tables of the motion of the Moon, and who wrote a major astronomy textbook.

Uranus was discovered on the night of March 13, 1781 at Bath, England, by another devoted observer, William Herschel, who recognized it immediately as an object possessing a discernable disk (unlike stars, which appear as points of light). Herschel's ability to detect this difference was enhanced because he used high magnification on a telescope he had made himself.

Johann Bode (of Berlin) and others since have uncovered over a score of Uranus positions that were observed and innocently recorded as a fixed star by star catalogers from 1690 to 1771.

Understand clearly: position recording is transit work, and is performed, therefore, with a low-magnification glass, customarily of very small aperture with concomitant poor resolving ability, and therefore quite unable to reveal the disc of distant Uranus or Neptune. The only hope of a transit observer recognizing a planet as remote as Uranus would be by its motion. And since the motion is rather slow (even at opposition, only about 4′ 30″ per day), a transit-cataloger would notice it only by comparison of observations taken on different nights.

But such comparison wasn't usually the intention of pioneer star catalogers.

Of the 23 known accidental "pre-discovery" observations of Uranus, the industrious Lemonnier alone made 12 between 1750 and 1771 — over half the set. More remarkably, he had observed the planet eight times in less than one month (between Dec. 27, 1768 and Jan. 23, 1769) ending with a Uranus observation every night for four straight days (Jan. 20 to 23). Yet he allowed the prize — the new planet — to slip through his grasp.

These bare facts have virtually dictated the verdict of history: Lemonnier was an oaf. To add insult to Lemonnier's self-inflicted injury, the four straight observations were published in 1818 by Alexis Bouvard, who pretended they were his own finds. As we shall see, Lemonnier's notes in the margin of his data books —from which Bouvard lifted the data — show that Lemonnier knew the full tragic story. In sheer embarrassment, he chose to leave it out in left field with the ex-Giant's radio, restricting his revelations to the publication, around 1789, of the earliest three position data he knew, those of 1764-1768.

After the full damning dozen were published in 1818, however, slandering the departed Lemonnier became a popular diversion. He was liberally attacked and lampooned for prejudice or untidiness or both. These charges are repeated, often innocently, even today (see the *Griffith Observer*, February 1980).

Two quotes, published in organs of two of our most eminent universities, illustrate pointedly the enduring popularity of slandering Pierre Lemonnier:

"[Lemonnier] had actually seen the star on four successive nights in 1769 *without noting the motion* that could have suggested another nonstellar identification. . . . A celestial body that had been observed off and on for almost a century was seen differently after 1781 because. . . it could no longer be fitted to the perceptual catagories. . . provided by the paradigm that had *previously* prevailed." [emphases added] — from Thomas Kuhn, *Structure of*

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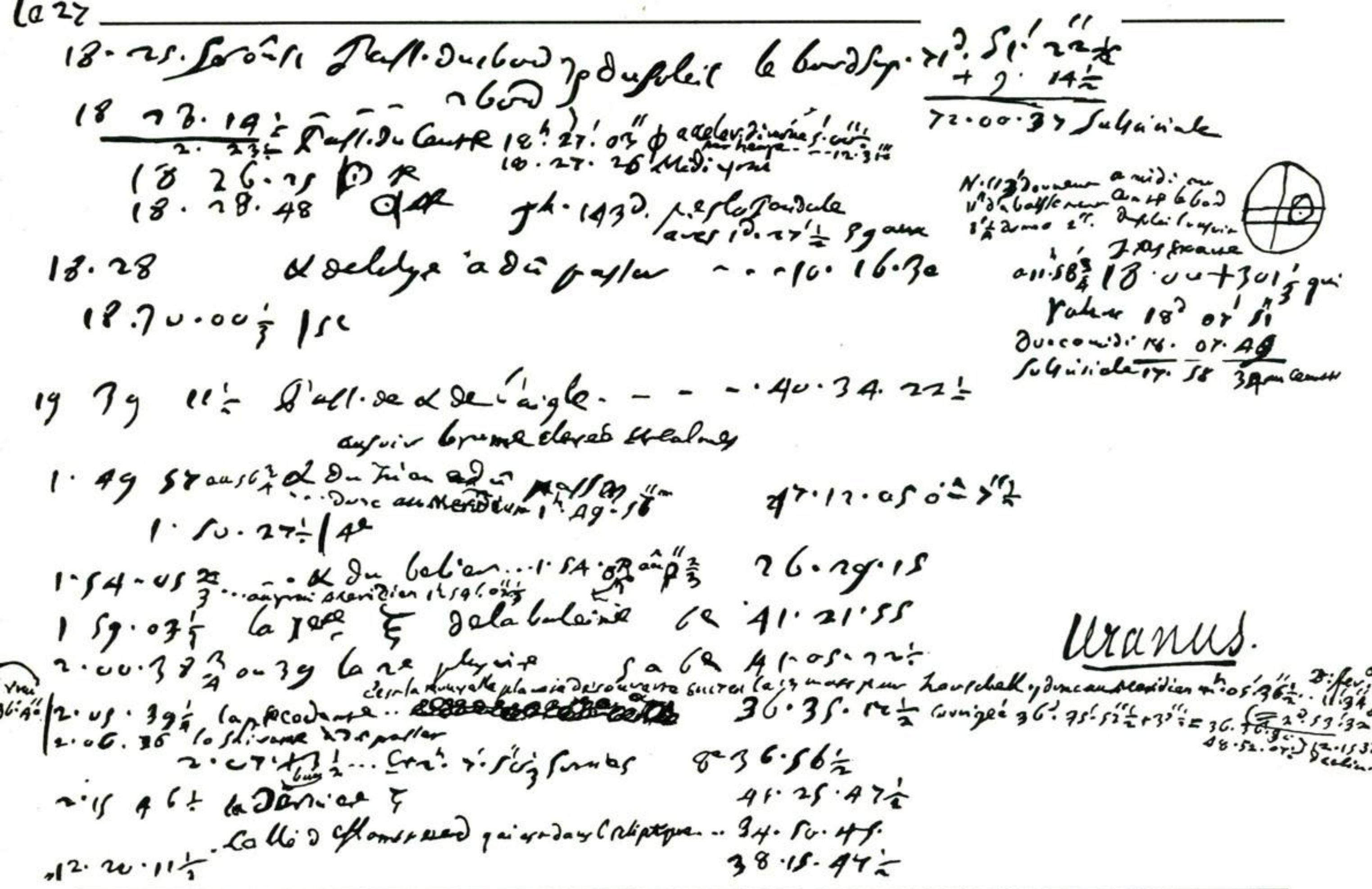

Uranus.

Part of the page of Pierre Lemonnier's record book, reproduced actual size, for the night of 27 December 1768. The notation "Uranus" is in Bovard's handwriting. Lemonnier has written *"c'est la nouvelle planète découverte sur 1781 la 13 Mars par Herschell; donc au meridien* 2h• 05'• 36"½" just above the Uranus observations.

Scientific Revolutions, 1962, U. of Chicago Press, pp. 114-115.

Fancy that. And:

"In January 1769 Lemonnier had observed Uranus six times in nine [evenings], and if he had re-examined his notes he probably would have discovered the new planet [from its motion]. Lemonnier did not, however, keep very tidy notes; one of his observations of Uranus was recorded on a paper bag that had originally contained hair powder. It was a novel and thrifty system, but not one that facilitated revealing comparisons."

— from Morton Grosser, *The Discovery of Neptune*, 1962, Harvard Univ. Press, p. 41.

Excellently told. And devastating.

The delightful hair powder bag tale is from the mid-19th century popular astronomy of Francois Arago, Director of the Paris Observatory (whose office was but a few meters from where Lemonnier's databooks were preserved, records he called "the image of chaos") — and as authoritative a source for the story as one could hope to come upon.

Now we see immediately that these accounts exhibit a common thread: a lesson must be learned from this incident (albeit the lessons to be drawn are quite contrary in the two little sermons).

However, having consulted Lemonnier's actual registers at the Paris Observatory, I will draw some lessons of my own:

Lesson 1. Those who think they are drawing lessons from facts are often doing the reverse.

Lesson 2. Accusations of sloppiness should not be sloppier than actions of the accused.

Lesson 3. If an academic ever takes leave to draw lessons from a consideration of your life, hie thee to a libel lawyer or (the budget option) seek sanctuary on an undiscovered planet.

Before turning to what I found in Lemonnier's records, I will note in passing how odd it is that Galileo and Michel Lalande are not savaged as lustily as Sloppy Pierre. Both men observed Neptune repeatedly, in 1613 and 1795 respectively, and noted the discrepancies of position in their records — yet neither made the discovery of that planet.

Again, we must keep in mind that all 31 known prediscovery records of Uranus (23) and Neptune (8) — not counting John Herschel's previously unremarked July 14, 1830 uncognizant midnight glimpse of the latter — were at such low magnification and aperture as to rule out discerning the disk. This is a simple matter of optics and thus has nothing to do with "paradigms." Note that Lalande's and J. Herschel's misses — as well as two innocent sightings of Neptune — occurred after the supposed paradigm-edge year, 1781, on which Kuhn lays such stress.

In 1970 I visited the Paris Observatory. There on display was Lemonnier's mural-arc transit instrument. With the cheery and amiable assistance of Martine Feissel, I located Lemonnier's fifteen large volumes of hand-written observations, the legacy of almost a half century of faithful celestial attendance — much of it carried out *in order* to have reliable ecliptic star positions for the improvement of lunar theory — for which his thanks

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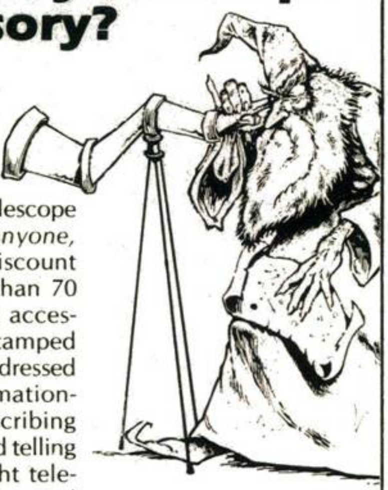

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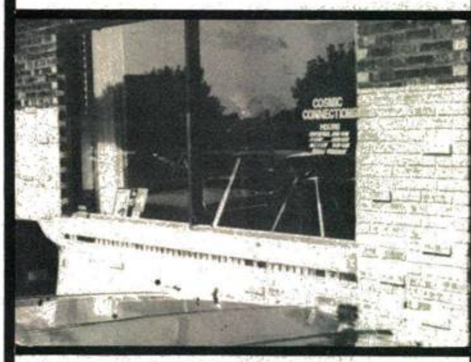

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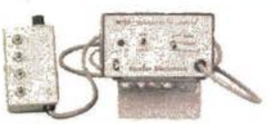

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COSMIC CONNECTIONS

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have been two centuries of derision.

Naturally I wanted to see the famous hairpowder bag, and so turned right away to the 12 Uranus entries. Pop went the legend: no bag.

To the contrary, every entry was continuous, in ink, in non-looseleaf, pre-bound registers. It had been done just the right way, the way astronomers have long warned students to record data so they wouldn't come to the hellish grief of poor Lemonnier.

It is gratifying to be able now to reconstruct just how the Sloppy Pierre hairpowder bag legend likely originated. Two things seem not to have occurred to those who relayed the tale:

(a) Arago apparently never consulted the original data books — he simply expanded upon Bouvard's account, just as later writers expanded upon Arago's.

(b) Bouvard had powerful cause to discredit Lemonnier's work.

The reason Bouvard went digging into Lemonnier's records in the first place was this: He had been appointed by France's leading astronomer, Pierre Laplace, to revise the theoretical orbit of Uranus. He was charged with finding an orbit that would satisfy all the available data, from 1690 to 1819. Bouvard soon found that it couldn't be done. The reason, we now know, was the large disturbance of Uranus' motion by the undiscovered planet, Neptune. To his credit, Bouvard suspected, by 1821, an "alien and unperceived action" upon Uranus. In the famous preface to his 1821 tables of the motions of Jupiter, Saturn, and Uranus, Bouvard resolved his dilemma by claiming that all the pre-1781 data were crude and untrustworthy, thus justifying his throwing out all of them. This enabled him to find an orbit which satisfied the relatively short post-discovery arc of Uranus' motion between 1781 and 1819.

Bouvard wanted desperately to play up anything that would cast doubt upon the accuracy of the astronomer who had made more of the prediscovery observations than everyone else put together.

We now know how grossly wrong Bouvard was. Lemonnier's Uranus positions, even using Bouvard's imperfect reductions of them, exhibit an average longitude error of 6″ — ten times smaller than the huge and curiously systematic errors Bouvard's 1821 calculations ascribed to him — errors which were simply Neptune's unaccounted-for perturbations in disguise.

And so we see why Bouvard made such a thing of Lemonnier's sloppy penmanship. Later, in the re-telling, this was transformed into scrap-paper record keeping and dubbed the image-of-chaos. . . .

If Lemonnier ever in his life scribbled a *calculation* (not an observation — as all these were properly recorded in the continuous entry record books) on a hairpowder bag, this would naturally come up in gossip as showing why such a slob would miss Uranus. Bag and Uranus having been thus juxtaposed, the next re-teller would have it that a Uranus observation was on the bag.

Another point: Lemonnier had many academic enemies and was a professor at the College Royal. Since his miss of Uranus appeared just as the French Revolution began, the snowballing portrayal of him as the-fool-who-missed-Uranus evolved in the post-1789 era. His powdered wig was an inviting butt of malicious humor — the classic symbol of the hated Old Regime he had served.

Also, Bouvard, a mathematician, may have lacked empathy with Lemonnier's December-January work, done in extreme cold, which is repeatedly mentioned in the records. The unlucky astronomer probably worked alone in the dark: observing objects transiting five vertical wires, making clock-tick estimates, adjusting altitude of the telescope, reading zenith-distance on the mural arc, dipping quill into inkwell, and then scribbling rapidly on the journal-page so he would not miss the next celestial object advancing on the transit-wires.

And why didn't Lemonnier compare his observations? I should be the last person to criticize him for this, as one may understand from the following.

I first laid eyes upon the Lemonnier records on Aug. 31, 1970. It is possible that I was the first astronomer to look through these registers since Alexis Bouvard in 1818. I photocopied the pages relevant to the dozen Uranus observations and, a week later, returned to the U.S. I then filed the copies away for a decade without looking at them. Recently, while overhauling the plotting of Uranus' orbit with Thomas Van Flandern of the U.S. Naval Observatory, I re-examined them. Only then did I realize the hair powder bag story was but a phase of the distortions that characterize this episode.

For starters: Bouvard in his 1818 report said Lemonnier had recognized three of his 12 Uranus positions ("a little too late" understates Bouvard) while leaving the impression without actually saying so, that he (Bouvard) had found the other nine. I found that the exact reverse is true. Bouvard discovered only two 1750 observations and one made in 1771. Lemonnier himself found the remaining nine, and roughly reduced a number of them, scrawling the figures on the page — not on scrap paper.

On the record of Dec. 27, 1768, we see in Lemonnier's infamous tiny script his recognition — perhaps his first — that he had let immortality slip through his fingers: "It is the new planet discovered in 1781 13th March by Herschell." It was possibly the worst moment in the life of someone who undoubtedly strove to do remarkable deeds.

At the entry for Jan. 20, 1769, the first of the fateful four days (previously thought unknown to him at his death in 1799), we see again his clear awareness: not only in the reduction in the margin, but also "4 days" written in his script, and over the observations "the planet."

In notes he scribbled upon the data page, right at his Jan. 16, 1769 observations, we come upon the most crucial information in the resurrection of Lemonnier's reputation: he there notes, for the entire stretch from Dec. 27, 1768 to Jan. 20-21, 1769, that the variation of Uranus' declination was but 1′.

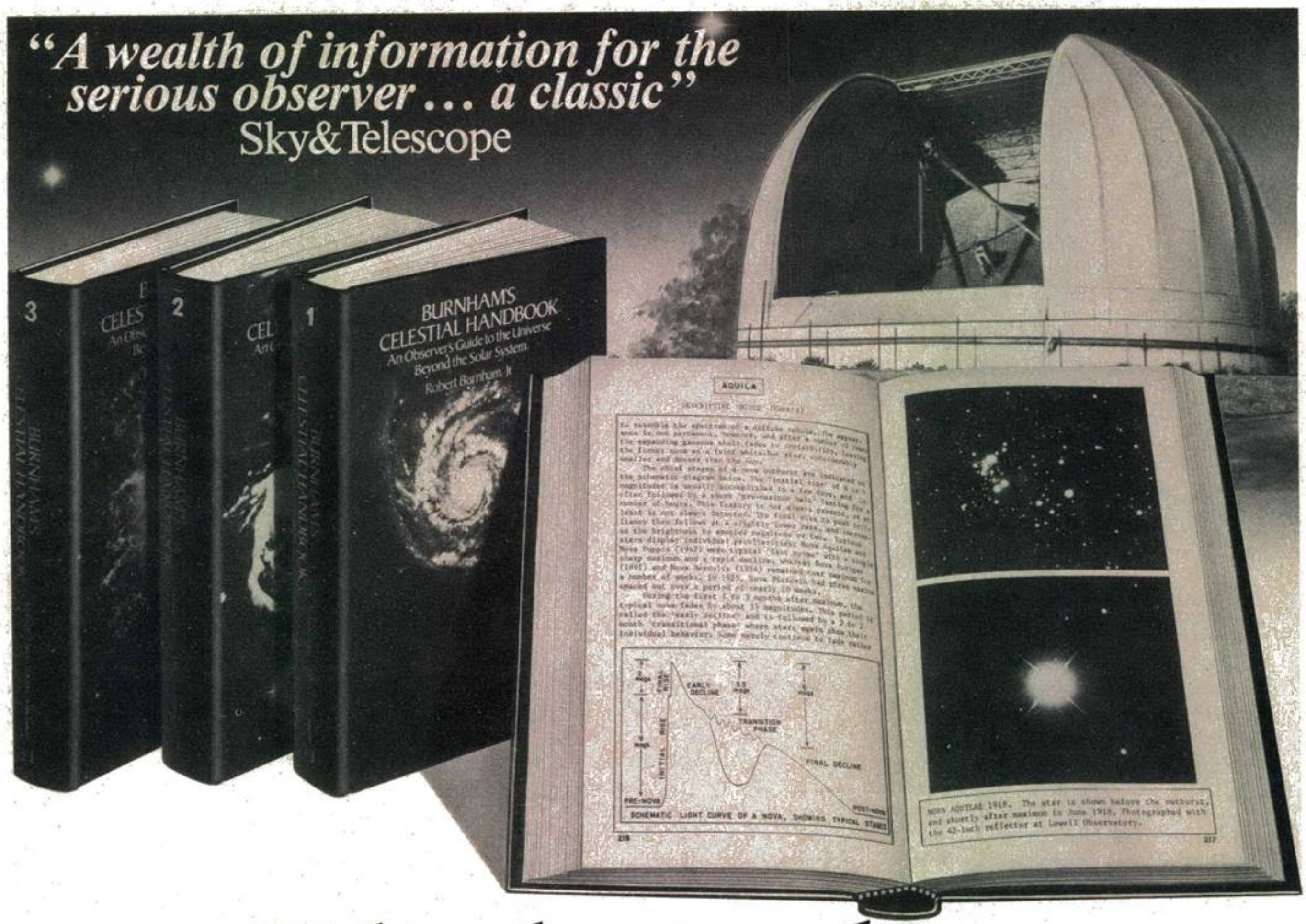
Upon reading this, I checked a table of modern computed Uranus positions for those dates and realized the same truth Lemonnier undoubtedly induced: when he made the eight 1768-1769 observations, the planet was passing through its *stationary point*. Its daily motion in this period was about 1 second west/east and 0.1′ south /north.

On Jan. 20 and 21, Lemonnier recorded a faint star following Uranus by about 1 second and about 5′ north of it. The largest evident "motion" was the accidental 1′ north/south error of the other star. Uranus' real northward motion in this one day interval was merely 0.2′ — only a fraction of the other objects entirely spurious "motion." It is from a blizzard of such records that hindsighters expect Lemonnier to have recognized a tiny real motion.

And so we have the spectacle of an astronomer who has been analysed, criticized, and reviled for 200 years for *not observing* the motion of a planet which was, in effect, *not moving*.

The irony of it all is so monumental that I will leave the reader to draw his own lessons from it. I'm cured of the habit for a while.

Dennis Rawlins
San Diego, CA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eye
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september: trios and conjunctions

by Fred Schaaf

the wanderers

Seven of Earth's eight fellow planets — all of them except Mars — are in the southwestern evening sky this month. As twilight deepens on the first of September, the view in the west is about as magnificent as the night before: three planets stand evenly spaced along a nearly straight line; the Moon has moved on but not too far. It is a promising beginning for a month with several more remarkable conjunctions.

The three planets in a row early this month are, from left to right — and in decreasing order of brightness — **Venus, Jupiter,** and **Saturn**. Of them, only Venus will continue to rise slightly higher each night. Steadily brightening (magnitude -3.5 becomes -3.7 by the end of September), our "sister" planet will be set little more than an hour and a half after the Sun at month's end.

Day by day, Venus will be moving eastward, away from Jupiter and Saturn and traversing the constellation Virgo, to pass just 4½′ of arc north of 4th magnitude Iota (ι) Librae on September 30. But the most striking event involving Venus will be its passage less than 2° north of first magnitude Spica, on September 6.

Even as Jupiter and Saturn seem to fall away from Venus, another planet — **Mercury** — is climbing up out of the Sun's bright glow to encounter them. Mercury will pass about 4° south of Saturn on the 10th and about 3° south of Jupiter on the 13th, thus making a "trio" with them briefly.

Last month, we informally called it a trio when three bright celestial objects were all within 5° of each other. In most years there are none, but from May 1980 to September 1981, no less than four such events have been or will be seen. The Great Conjunction of Jupiter and Saturn began last fall with a Venus-Jupiter-Saturn trio in the predawn sky which repeated late last month in the evening sky.

By a lucky coincidence, there are several other conjunctions during the few nights when the Mercury-Jupiter-Saturn grouping is most compact.

One of them will require binoculars or a small telescope to separate because the objects will be so near each other. This is an extremely close conjunction between fifth magnitude Uranus and a barely visible naked-eye star. On the afternoon of September 12, the distant planet will appear less than two Uranus-diameters away from the 5.5 magnitude 41 Librae. Telescopic observers who live in the eastern hemisphere may see the star briefly occulted by an as-yet-undiscovered ring or moon of Uranus. But those in North America will have to wait until sunset to compare the two with binoculars — or possibly even the naked eye — in very clear, dark skies. Which looks brighter to you?

On the same evening (the night of September 12/13), at almost the same time Mercury is passing south of Jupiter, Saturn is passing just 37′ south of Gamma (γ) Virginis (Porrima), which should still be visible low in the west if your sky conditions are good.

Before the Sun rises on the 13th — at about 5 a.m. local daylight time — **Mars** (which rises almost 4 hours before the Sun) will be in the middle of M-44, the Beehive star cluster in the constellation Cancer. To the naked eye, the cluster looks like a round dim patch of light, but even the simplest optical aid will resolve the light-patch into stars. Mars, at magnitude +1.8, will be easily visible as a reddish "star."

But don't look just on the 13th! Go out every clear morning for a week before and after to watch how the planet first approaches the cluster and then passes through and away from it.

Observing the configurations of Mercury, Jupiter, Saturn, and Spica in the last half of September will require an unobstructed view to the west — and you'll find haze-free skies and binoculars very useful. Those of you who enjoyed this year's Great Conjunction of Jupiter and Saturn will want to follow them and their cohorts as long as possible as they fade down into the Sun's glow. What's the last date that you can sight each of them with the naked eye? With binoculars? (Using a telescope is cheating!)

On the evening of September 20, Mercury (magnitude +0.3) is only 23½′ south of Spica and both lie a full 26° from the Sun. Mercury reaches greatest eastern elongation (26.3°) on the 23rd. But even then it sets only about 45 minutes after the Sun for viewers in mid-northern latitudes. (More southerly observers have an advantage in seeing all of these objects higher at this time of year.)

From 40° N., Jupiter and Saturn set only about 35 minutes after the Sun on the 20th and only 20 to 25 minutes after on the 28th. Want a tough challenge? Try to observe Jupiter on September 28 when it will lie near a very skinny crescent Moon — less than 18 hours old as seen from the east coast and less than 21 hours old on the west coast.

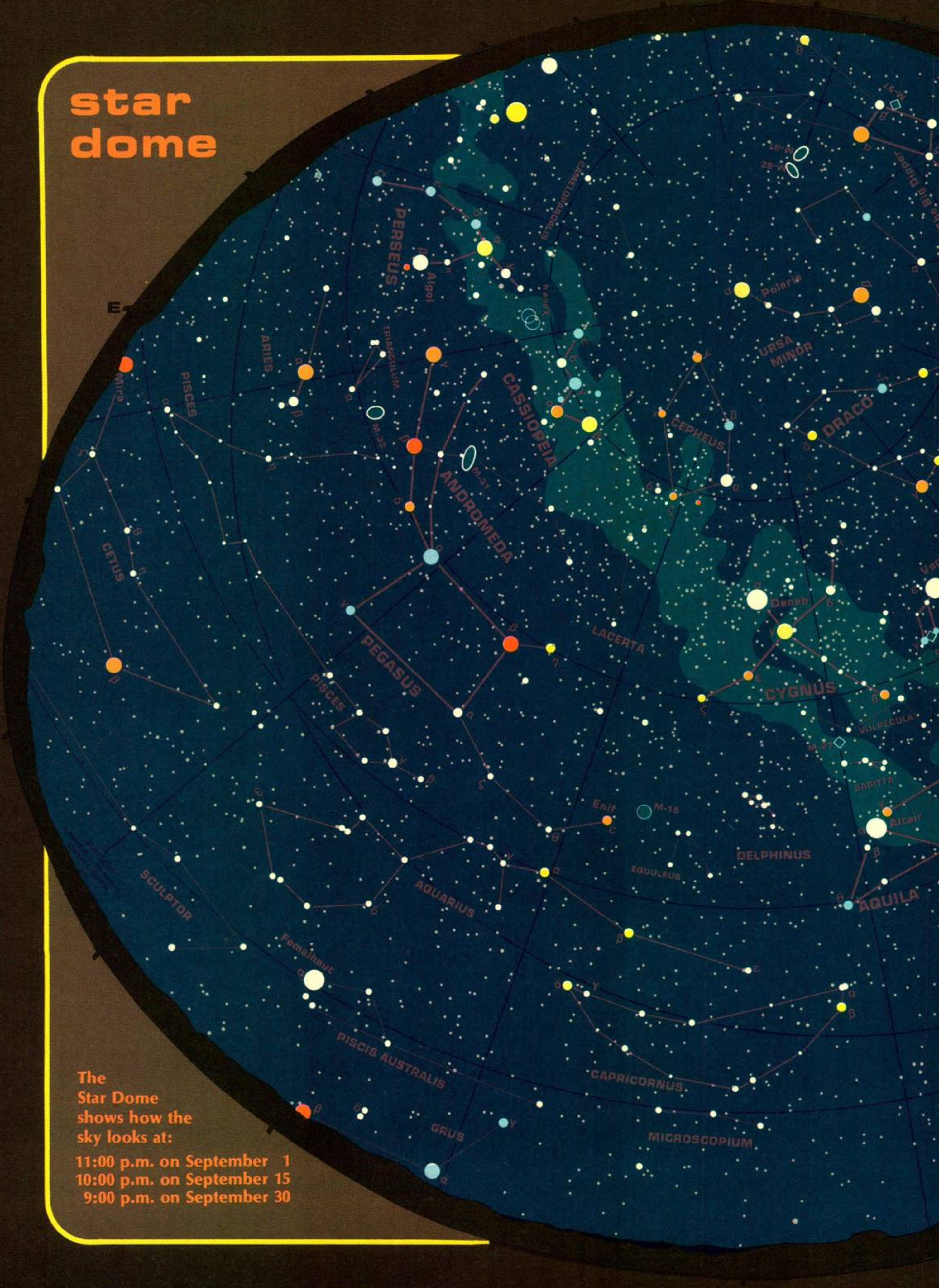
the starry sky

Although autumn officially begins at 11:05 p.m. EDT on the 22nd, September is possibly the best month of all for observing that giant asterism formed from the brightest stars of three constellations — the **Summer Triangle**. At mid-evening, two of its stars, **Vega** and **Altair**, lie just past the meridian and the third, **Deneb**, is nearly overhead.

Last month, we looked at sapphire Vega, but there are other stars worth

An early morning line-up of Jupiter, Saturn and Venus (top to bottom) breaks through a sunrise cloud bank. Johnny Autery made this 8-second exposure with a tripod mounted camera, 50 mm f/1.4 lens and Kodachrome 64 film. Many similar conjunctions will be visible in the early morning skies during September.

star dome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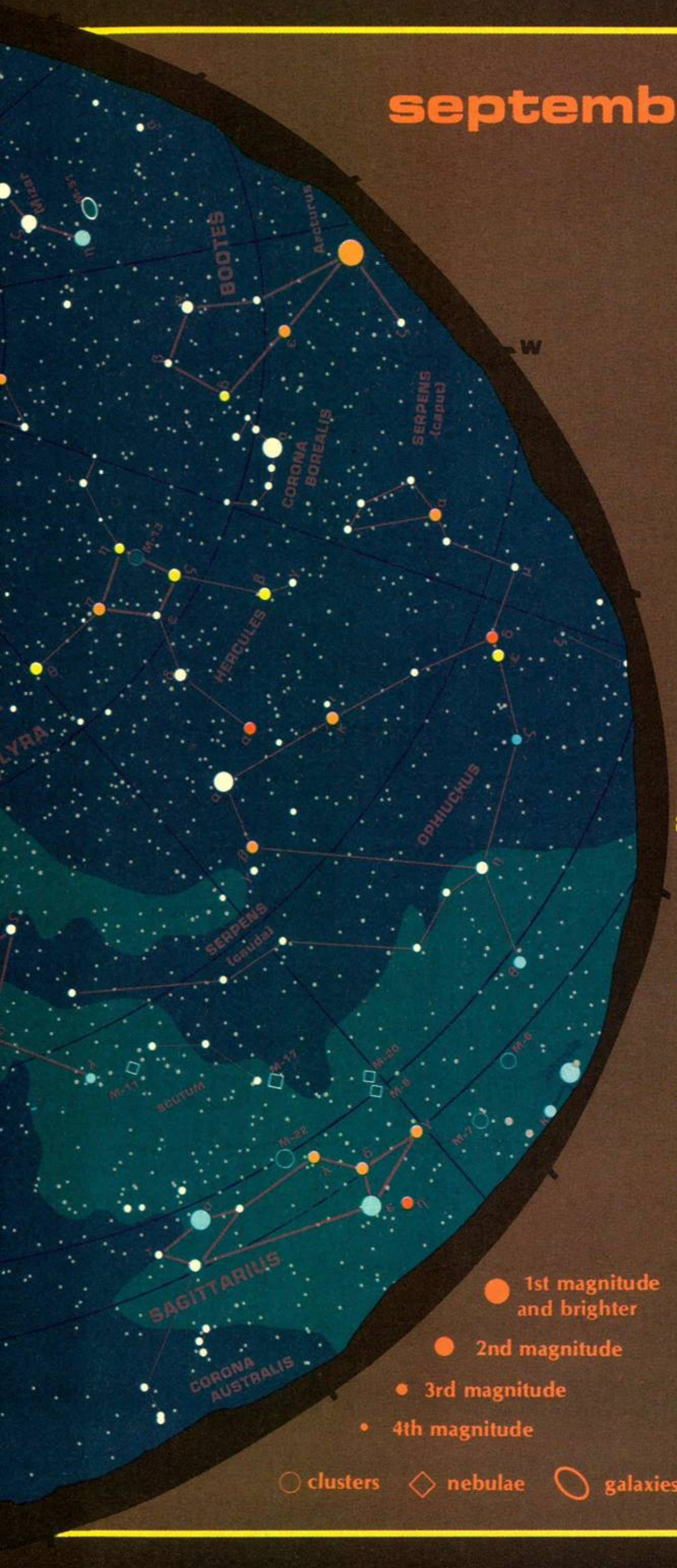
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M-17
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M-8
M-6
M-7
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CORONA AUSTRALIS
1st magnitude and brighter
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3rd magnitude
4th magnitude
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5th	The Moon is at apogee early this morning: 251,312 miles away.
6th	First Quarter Moon is at 9:26 a.m. EDT.
13th	Before sunrise this morning, look for Mars in the middle of the Beehive star cluster. Full Moon comes tonight at 11:09 p.m. EDT. This is the Full Moon nearest the equinox, the "Harvest Moon." For several days before and after Full, the Moon rises only a little later in the evening each day. Also: Mercury will be below Jupiter and to its left tonight after sunset — look low in the west.
20th	Last Quarter Moon is at 3:47 p.m. EDT.
22nd	The equinox; the Sun crosses the celestial equator and moves into the south celestial hemisphere at 11:05 p.m. EDT tonight. Autumn begins for Earth's northern hemisphere.
23rd	Mercury is at greatest eastern elongation from the Sun. Try looking for it low in the west after sunset.
24th	A thin crescent Moon will lie near Mars before sunrise this morning.
28th	New Moon is at 12:07 a.m. EDT.

A very young Moon, only 29 hours old, is captured here descending in the west over Rapid City, South Dakota. Jeff Belet waited until a landing jet entered his field of view to make this ⅛-second exposure with a 300 mm f/5 lens on 200 ASA film. The youngest Moon ever detected visually was reported to be only 14 hours old.

noting in its home constellation **Lyra** the lyre. One of them, **Epsilon** (ε) **Lyrae**, just to the northeast of Vega, is one of the most famous multiple stars in the heavens.

A small telescope shows it as two close-together pairs of stars (which has earned it the nickname "the Double Double"), but can you see it as two separate points of light with your naked eye? Under conditions of good seeing and transparent skies, an observer with acute eyesight can see that the star appears slightly elongated. Try this test of naked-eye vision for yourself. (Of course, for a clearer view, use binoculars.)

Another notable star of Lyra is **Beta** (β) **Lyrae** (also named Sheliak), which changes brightness from a maximum magnitude of +3.4 to a minimum of +4.1 once every 13 days. It takes about 3 days to sink from full brightness to minimum and rise back to full again. Beta also has a secondary dip (to magnitude +3.75) about halfway through its 13 day cycle. Compare Beta to its neighbor Gamma (Sulaphat) with its 3.25 magnitude.

On very clear nights in dark skies, the **Milky Way** can be traced northward almost to the main pattern of Lyra, but even in the light-polluted skies of suburbia, one part of the band is often visible — the **Cygnus Star Cloud**. This large swath of light lies in the middle of the swan's prominent outline. Another piece of bright Milky Way to look for is the **North America Nebula**, just a few degrees east of Deneb. Though tracing its precise shape requires some optical aid, the patch itself is certainly visible to the naked eye under fairly dark skies.

The nebula is probably associated physically with superluminous Deneb. Although this star appears slightly fainter than Altair, in fact it lies about 1,000 times farther away. Deneb is thus intrinsically far brighter. If Deneb were as close to us as Altair, its brightness would rival the Moon's shortly before First Quarter.

Let's skip down the Milky Way past the Summer Triangle's southern point — Altair of Aquila the eagle —to catch some southern constellations before they slip out of sight.

But don't hurry too fast or you'll miss the **Great Rift**, whose dark form splits the Milky Way from Cygnus to Ophiuchus the serpent bearer. September is also one of our last chances to see properly the constellation **Scutum** the shield and all the splendors of **Sagittarius** the archer and **Scorpius** the scorpion.

The lengthening nights of autumn prolong our last views of Scorpius and the bright star clouds around the teapot of Sagittarius. But all too soon they'll be gone for another year.

Following southerly Sagittarius across the sky at a considerable distance is a boat-shaped star pattern highest at mid-evening in September. Capricornus the sea-goat — half-goat and half-fish — is a very ancient zodiacal creature. Notice the wide naked-eye double star **Alpha** (α) **Capricorni** (Giedi) at the western end of Capricornus.

Flooding across the southeastern sky is a vast and dark section of heavens sometimes called the **Celestial Sea** or the **Water** because of the "wet" nature of the constallations there.

Amongst all the blackness, one of the few bright beacons is the first magnitude star **Fomalhaut** (of Piscis Austrinus), still low in the southeast at mid-evening when autumn begins. Although this watery realm is sparsely starred, it is rich in unusual objects and starlore and it is very evocative of the autumn season. We will have much to look at here as autumn progresses.

But higher in the south and the northeast we can already admire some of the brigher constellations of autumn as they rise: the **Great Square of Pegasus** — formed by 4 second magnitude stars — and second magnitude **Enif** (Arabic for nose), one long flying horse's neck ahead of them in the race across the sky. The brilliant chair of **Cassiopeia** the queen is in the northeast and to her left **Andromeda** — the famous constellation and its even more famous galaxy.

skylore

Skylore is usually about the various legends concerning one particular constellation or star. But this month we'll deal with one great tale which unites — quite literally — two different asterisms. The tale is worth the treatment because it may be one of the most ancient legends to survive in something like its original form. And, though ancient, it remains one of the loveliest and most popular of oriental star myths.

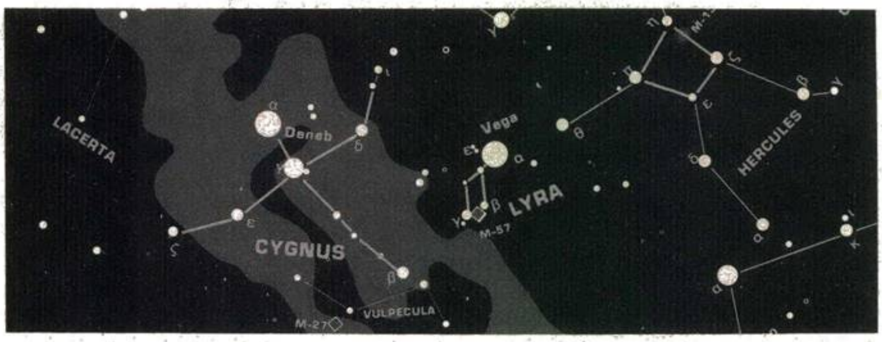
Our story concerns the two lovers who each year are reunited by a "Bridge of Magpies." The earliest mention of the legend occurs in the *Shih Ching*, or *Book of Songs*, which was compiled in the Chou Dynasty of the 6th century B.C., but even at that early time the telling of these tales was probably a time-honored tradition.

Ch'ien Niu was a celestial cowherd who fell in love with and married the maiden Chih Nu, daughter of the August Personage of Jade, the king of the heavens. Chih Nu was the goddess of weaving and spinning, and she made seamless cloud robes for her father.

The cowherd and his bride were so happy together they neglected their duties in the sky, and the queen of the heavens therefore pierced the celestial vault with a silver hair-pin to form the Heavenly River — the Milky Way — to lie impassably between the two lovers.

The spinning damsel Chih Nu is, variously, Vega, the little triangle of Vega, Epsilon and Zeta Lyrae, or all of our present-day Lyra. The cowherd Ch'ien Niu is Altair and the stars to either side, Beta and Gamma Aquilae (Alshain and Tarazed). One look high in the summer sky shows that indeed the Milky Way separates them, the maiden on the western shore, the cowherd on the eastern.

But the tale doesn't end here. The king of the heavens decreed that one night a year, on the seventh night of the seventh moon (mid-August), the lovers could meet. In order to make that meeting possible, all the magpies of the world would gather that night and form a fluttering bridge on which the lovers could come to each other.



Raindrops that fall during the big day are tears of joy for their meeting; those at night are tears of sadness for their parting. If any magpies are seen on the big day, they are scolded and shooed away by children.

The starry lovers have only one night, for when dawn comes the magpies must scatter back to their homes and the lovers must return to their respective shores to wait for their next meeting.

This beautiful tale was brought to Japan during the reign of Empress Kiken (749-759 A.D.) and became the basis for the holiday Tanabata — "seventh evening" — so named, of course, because it was celebrated on the seventh night of the seventh moon. In Japan, the cowherd is called Hikoboshi or Kengiu; the spinning damsel is Uri-hime.

The Korean version makes the man Ching Yu, a Prince who is separated from his bride by her father because of what R. H. Allen calls "the Prince's unfortunate scheme to tap the Milky Way and divert the fluid to nourish distant stars"! A much different Chinese version tells of Tung Yung, a youth whose fortunes were so bad that his whole family died, his father last of all, leaving him so poor that he had to sell himself into slavery to give his father an honorable burial.

Tung Yung worked so hard that he became very ill, but the king of the heavens sent his daughter Chih Nu down the Milky Way to the youth's sickbed. The sight of her and her love revived him and she became his wife, bore him a child, and made him wealthy with her tapestries.

When their child was at last weaned, Chih Nu returned to heaven, and the immortals greeted her with the gift of a beautiful castle which we now see as the star Vega. Chih Nu is one of the many lady weavers who play so large a role (I will not say "loom" large!) in legends around the world.

Of the many other related Chinese tales, another of the most delightful recounts the trip of the great explorer Chang K'ien. He lived during the Han Dynasty, more than 2,000 years ago, and had taken trade to the far land of Turkestan. But the greatest of all his travels was his trip to find if the great Yellow River might really have its source in the Heavenly River, the Milky Way.

Chang K'ien labored up-river until he grew so weary that he nodded off into sleep. When he awoke, the river had become gentle, floating him peacefully along between lines of willow trees. He drifted on, but after the Sun set he was filled with wonder by the sight he beheld.

As Gertrude and James Jobes relate: "A brilliant white light, more radiant than that of the Moon, outlined the landscape through the willow trees. Earth, as well as sky, was a deep sapphire blue; the stream beneath him was silver and reflected thousands of stars on its still surface. The stars were nearer and brighter than he had ever seen them." This sounds almost like a description of the night sky from a planet near the center of our galaxy, but there's more: "He knew he must be in the world above, and he continued on for days until he reached the Western Paradise, where the fragrance of the Peach Tree of Life intoxicated him. It grew beside a lake of jewels, its branches perfumed with cinnamon and herbs, its leaves rustling as birds with iridescent wings stirred among them."

Chang Ki'en saw many more wonders, but at last came to a white city on the shore of a river where he met a beautiful maiden weaving and, across the river, saw a herdsman leading oxen to the water to drink. When Chang Ki'en asked her what land this was, the maiden told him to take the shuttle from her loom back to his home and show it to Kun P'ing, the astronomer, who would tell him where he had been.

After the explorer's long journey home, he sought out the marvel-worker astronomer Kun P'ing and showed him the shuttle. When Kun P'ing heard the tale of the voyage, he told Chang Ki'en that he had been preparing to observe the annual meeting of Ch'ien Niu and Chih Nu when he saw a "guest star" — a comet, nova, or supernova — come between them. That guest star had been none other than Chang Ki'en!

ASTRONOMY IN FOCUS

Calculating Horizon Coordinates

Sir/The article "How to Calculate Horizon Coordinates" in the December 1978 ASTRONOMY has been very useful to us.

We live in a northwestern suburb of Milwaukee, and our eastern horizon is badly light-polluted. Only to the south and west and north and west can we see un-light-polluted sky. But in those same directions lie some buildings and trees that block certain lines of sight!

We used the printed formulae to write a BASIC program (for a TRS-80 home computer) that tells the best time to look for a and photograph a given object.

In the article, the value of "K" was provided only through 1981. A rummage in Sidgwick's *Amateur Astronomer's Handbook* (4th edition, 1980) turned up the following values of K for other years:

1982: 6.622408
1983: 6.606493
1984: 6.590579
1985: 6.640374

Richard Wiesen
John Wiesen
Brookfield, WI

Ed. note: Check ASTRONOMY's In Focus, June 1979 — you'll find a procedure for calculating the value of K for any year.

Success Story

Sir/ Until a year ago, I knew nothing about astronomy or space, but then my ninth grade science class got me involved and I subscribed to your magazine. At first I just tried to pick up the basics and ignored everything about equipment and telescopes. After a couple of months, though, I looked back at the first issues of ASTRONOMY I had received and found the articles on building a Dobsonian telescope. I was amazed that it looked so simple, and I went ahead with the project. For $300, I built a 10-inch Dobsonian!

I never dreamed of owning a telescope that big. I am now expanding my knowledge of the night sky, and my list of observed objects is growing swiftly — thanks to you!

Kevin Righter
Murrysville, PA

Mr. Righter: We have received dozens of letters and photographs from people who built the 10-inch Dobsonian described in Equipment Atlas in the June, July, and August 1980 issues of ASTRONOMY. We know from our own experience how nicely this telescope performs, and are pleased that others now share the hobby of astronomy because of it.

The Military Connection

Sir / Both articles in your April Forum take the Reagan administration to task for its lack of support for the space program. Unfortunately, Donald Robertson does so for all the wrong reasons.

Mr. Robertson stresses the military aspects of our space program vis-a-vis that of the Soviets. This is regrettable. The idea that NASA expenditures are a quasi-military form of defense spending has been a major cause of the erosion of liberal support for the U.S. space program.

Our expansion into space should have been helping us put this sort of parochial nonsense behind us. All of humanity — from Bangor to Bangladesh — was enriched the day an American walked on the Moon. So will it be again if a Russian walks on Mars.

Jim Klann
Mt. Prospect, IL

SMM Clarification

Sir / Some clarification of the relative temperatures of the layers of the solar atmosphere should be added to your article on "The Solar Maximum Mission" (May 1981, p. 9). The chromosphere is hotter than the photosphere, contrary to the statement in the article. The temperature of the Sun declines as you go outward through the photosphere and reaches a minimum temperature of 4200°-4500° at a point in the upper photosphere/lower chromosphere called the "temperature minimum." Then the temperature rises rapidly throughout the chromosphere and lower corona. Typical chromospheric temperatures are 8000° to 15,000° K.

The reason the H-alpha radiation is important in the chromosphere was also incorrect. We can distinguish two cases: looking right at the solar disk and looking off the solar limb. In the first case, we see downward through the gaseous layers of the Sun until the accumulated opacity (how opaque or transparent the gas is) prevents us from seeing any farther. In most of the spectrum, we stop seeing at more or less the same height in the solar atmosphere. This height is, by definition, the photosphere. In hydrogen-alpha, on the other hand, the opacity of each bit of gas is higher than it is at other wavelengths, so we stop seeing farther up. For H-alpha, we stop seeing in the chromosphere, which is why we see the chromosphere through an H-alpha filter. In the second case, off the limb, we are seeing hot gas silhouetted against a dark sky, and thus see the H-alpha as a bright emission line.

Contrary to the statement in the article, we see H-alpha not because the gas is cool but rather because the gas is hot. The electrons recombine with the protons to form hydrogen that is "excited." H-alpha is emitted by such excited gas as it returns to a state of lower energy.

Jay M. Pasachoff
Honolulu, HI

Constellation Controversy

Sir/ Browsing through various encyclopedias and astronomy books, I have noticed a profound difference in the way authors present constellation forms. Some are only slightly changed, but others contradict. Hopefully, astronomy is not allowing authors to have a type of poetic license. Are there, in reality, many variations?

Jed Brewer
Moroni, Utah

Mr. Brewer / The official boundaries of the constellations are set by international agreement among astronomers, but the lines used to connect the stars into a pattern are generally left to the individual. In many cases, there are accepted ways of portraying mythological figures — Orion, for example, or Cygnus — but there is no reason to stick with an author's configuration. You can even make up your own constellations!

Early Tektite Tools

Sir / I am writing in regard to the fine article by Joel Davis entitled "The Tektite Controversy," (ASTRONOMY, April 1981.)

I found Mr. Davis's article very well informed and timely, but one aspect of it can now be updated by recent research.

During March of this year, I was the staff archaeologist on a joint Smithsonian Institution/Egyptian geological survey expedition to the Libyan Desert glass strewn field near the Libyan border.

Based on research conducted there in previous years, I was able to confirm that the history of human utilization of Libyan Desert glass extends back at least 200,000 years. We discovered large numbers of Lower Palaeolithic Acheulean stone tools, including a small hand ax made of the glass. This now constitutes the earliest known use of tektitic glass.

John W. Olsen
University of Arizona
Tucson, AZ

Commercial Astroprocessing

Sir / In response to Michael Covington's letter (ASTRONOMY, May 1981) about getting commercial prints of astrophotos: I'm an amateur astronomer working for a color processing lab. I've spoken to my boss about the problem, and we are currently writing a mini-program for the printing computer to give the nice "black sky" treatment to astronegatives — rather than the usual ugly green or brown.

Anyone who's willing to work with color print film (C-41 process only) and who would like standard 3R prints of their astro-negatives can send me a stamped self-addressed envelope. I'll send them a price list in it.

At present, we can't offer custom enlargements or slide film but we hope to in the near future.

Kenneth S. Hulme
833 Cottonwood
Loveland, CO 80537

Crowded Skies

Sir / While browsing through the July 1980 issue of ASTRONOMY, I noticed Douglas Tucker's letter asking about a strange point of light moving across his telescope's field of view. In your reply you stated that he probably saw a satellite.

I own exactly the same type of instrument that Mr. Tucker does, an RV-6 Dynascope. During the 2½ years that I have used it, I have unintentionally sighted at least half a dozen satellites moving slowly through the field of view. I have also spotted one or two that were bright enough to be seen with the naked eye.

Perhaps this serves as testimony to the fact that the skies are indeed becoming "crowded."

John Hayes
Mt. Morris, IL

behind the scenes

moving on

ASTRONOMY has moved! On June 21 our address officially became 625 E. St. Paul Avenue, here in Milwaukee. For the past six months, we've been working with architects and contractors renovating the new AstroMedia building, a 20-year-old former bar and nightclub located a few blocks from downtown. All the former fixtures, including a fortune in mirrors, sun-drenched mediterranean waterfront scenes, marble archways, aquariums, and stone fireplaces were removed, and a bright, open and airy new office was constructed for ASTRONOMY and ODYSSEY.

We now work out of a two-story Lannonstone-faced building with 10,000 square feet of space. The editorial, production and administrative offices are on the second floor, and the subscription, fulfillment, and shipping departments are on the ground floor.

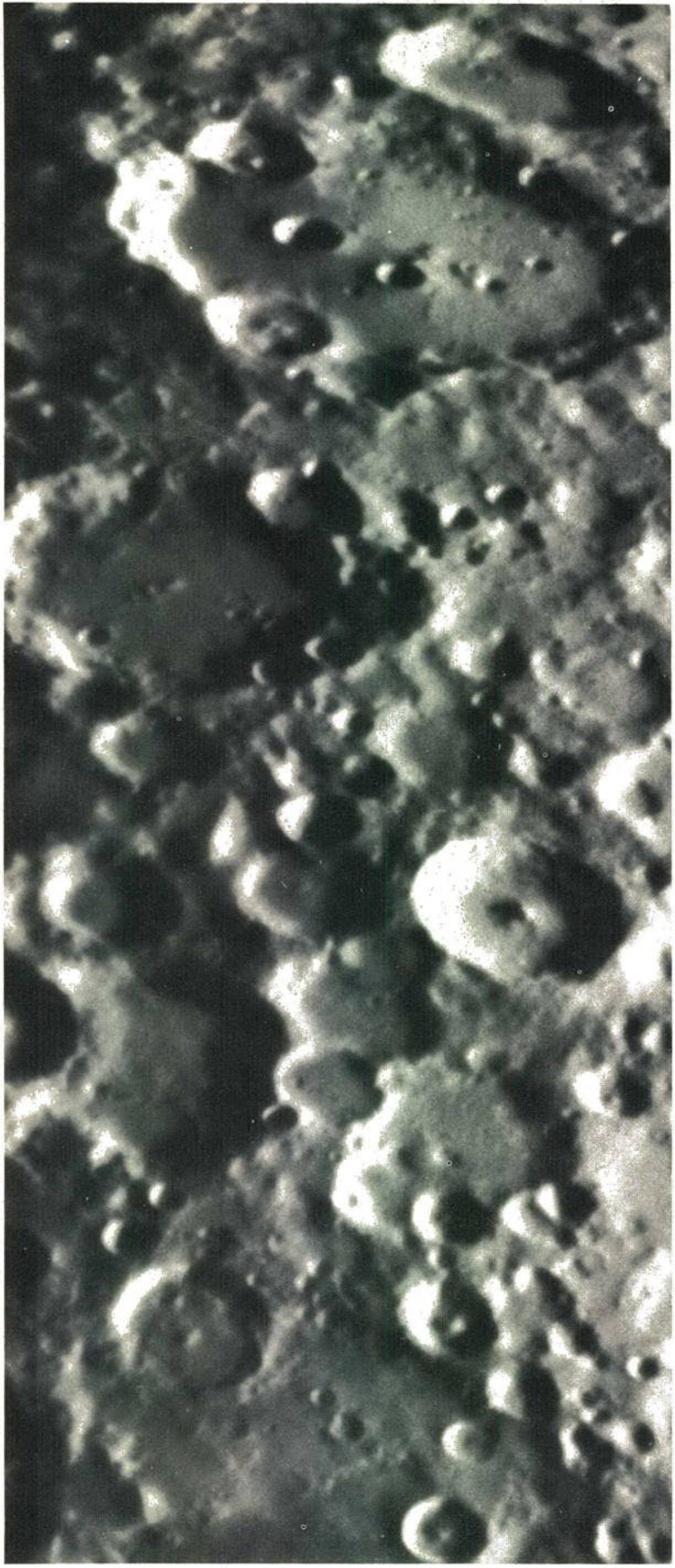
With reams of editorial copy to write, thousands of subscriptions to renew, printer's deadlines to meet, and tons of records to transport, the move required tight coordination. Special mention goes to Stephanie Kiel, our administrative assistant, for taking on much of the planning and organization.

Meanwhile, we want you to know about our subscription service hotline. If you have a problem, call (414) 276-8547 and we'll do our best to straighten things out. Hotline hours are 8 a.m. to 4 p.m., Central Time. Athough we have 160,000 copies of ASTRONOMY and 70,000 of ODYSSEY in circulation, we still want to make sure that every reader has a trouble-free subscription.

Sincerely,

Richard Berry

Richard Berry
Editor



This detailed photograph of the moon showing the crater Clavius and surrounding area was taken with the Questar 3½. A new edition of QUESTAR OBSERVATIONS, *includes some other beautiful moon photographs from our files and is available for the asking.*

One thing leads to another here at Questar

Our original work in revolutionizing the astronomical telescope has certainly led us into some mixed company and into some remarkable digressions over the years. We have discovered astronomers using their Questars for bird watching in the daytime, and bird watchers turning their Questars on the moon at night—a reverse curiosity that is natural when you own a telescope that should never be idle. A Questar® can bring new compatibility to a sky watcher-bird watcher relationship.

Furthermore, specialists in many fields who would never think of using a telescope are turning to Questar for the solving of technological problems in this optical age when fine optics are an important adjunct to so many disciplines. A recent case in point is our development of the Questar 40-120, a patented system which establishes prime focus at both 40 and 120 inches. Other lenses, particularly the zooms, can vary their focal length but with a compromise of quality and relatively low magnification. The 40-120, however, resolves 100 lines per millimeter at the lower focal length and at least 55 lines at the upper, and one can move in a few seconds between the two. This sophisticated system serves a variety of uses where the observer must be at a great distance from the area under scrutiny and it is particularly important for observing objects in motion.

We think one of our most exciting new instruments is the Micro-Questar, developed for laboratory research. This is a microscope of unique character which fills a gap between the low-powered dissecting microscope and the large scanning microscope. Its focusing range is from 37 to 96 inches, with a range of magnification from 56 to 666 diameters. It fills a long-desired need, the ability to observe a specimen up close without destroying it or removing it from its environment. Recently at MIT we watched in fascination the motion of minute copepods moving about in an aquarium in response to a magnetic field which surrounded them. With the Micro-Questar placed 37 inches from the copepods, the sight path was through the magnetic field itself.

We don't like to leave without mentioning again our Questar 700 which has had a remarkable history since its introduction four years ago. Designed for the photographer as an f 8 telephoto lens with our new patented feature, flatness of field from edge to edge, it has now displayed some other talents that please the astronomers. With the addition of an eyepiece it is a beautiful rich field telescope, and it complements both the Questar Seven and the Twelve as a wide-field photographic lens for the deep sky.

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the pleasures of deep sky observing

gazer's gazette

by David Eicher

I've been a "deep-sky addict" for years and, despite the attractions of lunar and planetary observing, I have never lost my fascination with the universe beyond the solar system: double stars, open and globular clusters, planetary and gaseous nebulae, and those far-off, slowly whirling stellar pinwheels — galaxies. This month is an excellent time to make your acquaintance with deep-sky observing since a wide variety of objects is visible during a single night.

Because deep-sky objects are dim, the best times for observing come during the "dark of the Moon." From Last Quarter through New to First Quarter, the Moon interferes least, so if you want to get started, the first or last week of September should be the best. How far from city lights must you go? You'll probably be able to see most or all of the objects listed here from a reasonably dark suburban site — but every one will look a whole lot better under really black rural skies.

If you don't know your constellations already, take the trouble to spend a night or two naked-eye sky watching with a planisphere or ASTRONOMY's Star Dome. You'll soon develop a very useful familiarity with the sky. A good star atlas is a must — the *Atlas of the Heavens* by Antonin Becvar or the *Sky Atlas 2000* by Wil Tirion are both excellent. Also useful, but not as detailed, is *Norton's Star Atlas*. Atlases help you plot a night's sky-tour so you don't waste precious time scanning haphazardly back and forth.

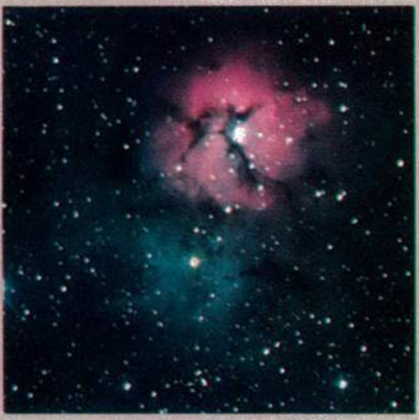
An equatorial mounting for your telescope is less important than you might think — with a little practice, you can "star-hop" from object to object. Star-hopping is easier than laboriously setting up and aligning an equatorial mount every time you observe.

Lastly, to check charts and equipment in the dark, you'll need a flashlight — but cover the lens with several layers of paper to reduce its brightness (red works best).

Evening

A good starting point for your deep-sky tour is Messier 8, the Lagoon Nebula in northern Sagittarius. This favorite of many observers lies, as do several other targets, in the direction of the center of our Milky Way Galaxy.

The Lagoon is a bright (5th magnitude) emission nebula — a vast cloud of ionized hydrogen gas, excited to luminosity by the fierce radiation of a hot O-type star. It lies some 3000 light-years distant. The actual diameter of the nebulosity and associated star cluster which has condensed from the gas measures some 100 light-years — 1/1000 of the diameter of the entire galaxy.



Orien Ernest

M-20, the Trifid Nebula

A low-power, wide-field eyepiece works best for this object. When you locate it, the first thing you'll notice is the star cluster, NGC-6530. This great open cluster contains 60 stars and has an *integrated*, or total, magnitude of 7.7. Adjacent to the cluster is a fairly faint patch of greenish-white nebulosity and, separated by a dark band of interstellar dust, a brighter roundish patch. Take more than a quick glimpse — really look. At low powers, the Lagoon is a grand sight.

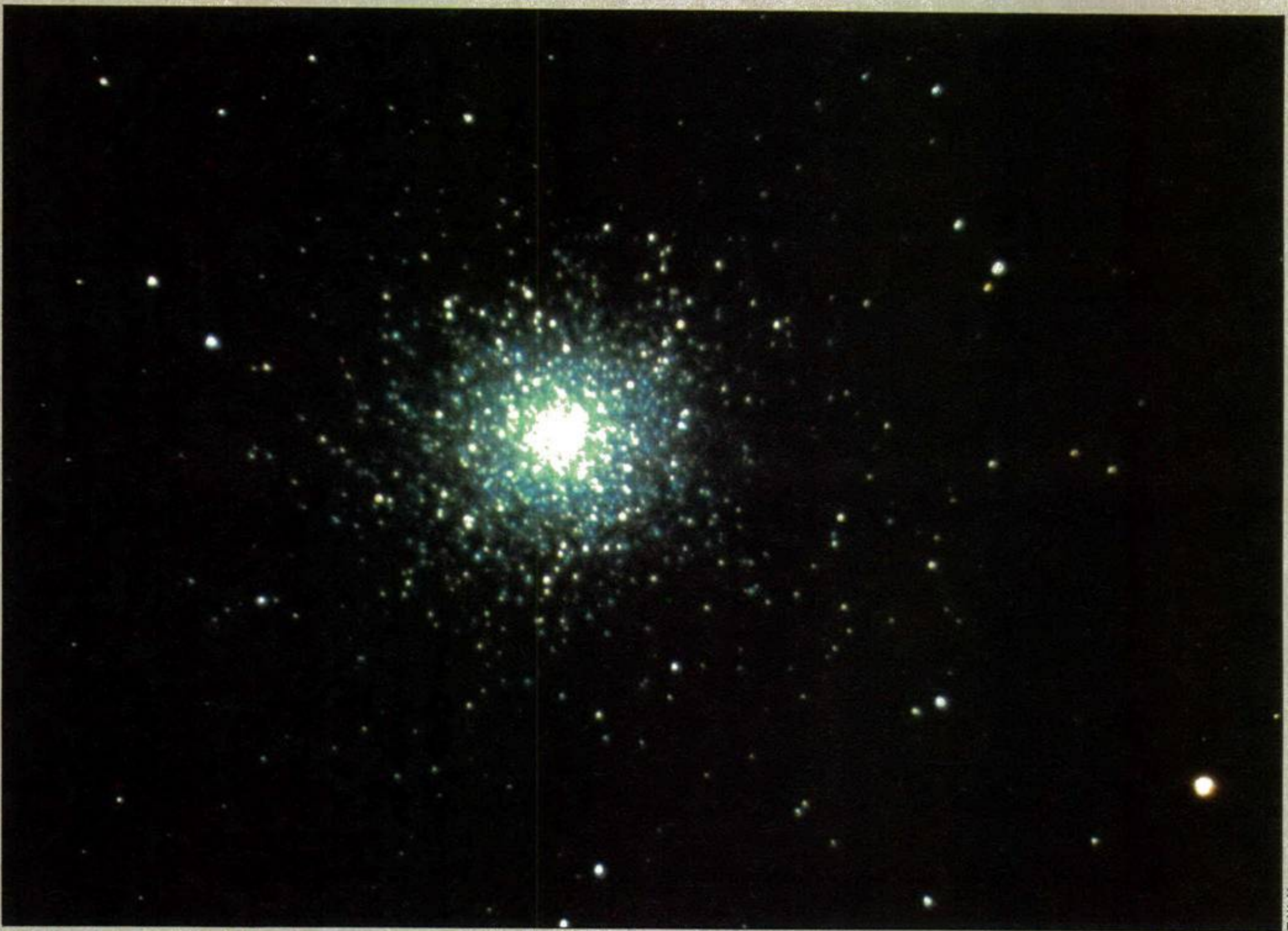
After you've marveled at M-8, take a look at another emission nebula, M-20, just 1½° north. Messier 20, nicknamed the Trifid Nebula due to its three intersecting dark lanes, is much fainter than M-8, and measures about one-third the angular extent. Many people describe the Trifid as a "large, milky object" — after seeing it, you'll know why.

It has what observers term a very low *surface brightness* — which means that while its integrated brightness may be great, the light is spread around, so individual parts of the nebula are pretty dim. For this reason, M-20 shows best on very dark nights when the atmosphere is very steady.

You can find M-20 with the same low-power ocular you used for M-8, but once you find it, switching to a slightly higher magnification will yield a darker sky background in the viewing field and may increase contrast.

Just north of the bright emission portion of M-20 lies a dimmer reflection nebula that shows up blue in color photographs. The light from the nebula's hot bright stars is reflected by particles of dust. The reflection nebulosity and the dark structure superimposed across the emission region are tough targets. Don't be discouraged if you can't spot them on your first few attempts.

Let's move on from emission nebulae and take a look at two of the finest globular clusters visible from northern latitudes — M-13 and M-22. Messier 22 lies 2.3° northeast of Lambda (λ) Sagittarii and floats high above the plane of the Milky Way about 10,000 light-years away. Astronomers think its stellar population may exceed half a million, and some 75,000 individual stellar images have actually been counted on a single photographic plate! M-22,


Bill Iburg

M-13, the Great Globular in Hercules

with an integrated magnitude of 6.5, can be seen easily in any telescope, and is a truly magnificient sight in medium to large aperture instruments.

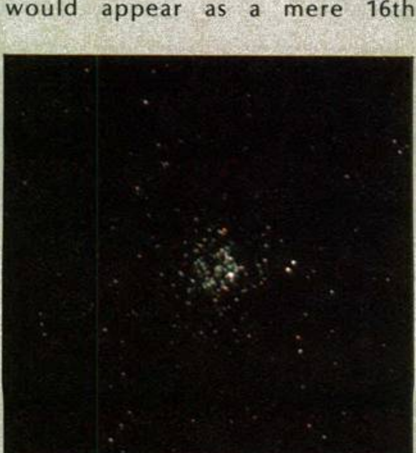
Messier 13 lies in the "keystone" of Hercules and is 2.5 times more distant than M-22. The apparent diameter of this cluster measures 23 arc-minutes on photographs — somewhat larger than M-22's 17 minutes of arc — but neither cluster will appear particularly large through the eyepiece. The comparison between what you can see and what the giant professional telescopes can photograph is impressive.

A good 4-inch telescope will start to resolve the outer edges of M-13 into its constituent stars and will produce a mottled appearance on its face. M-22 resolves with even less instrumentation. Under really good conditions, use high magnifications on these clusters. When you resolve their outer regions, multitudes of tiny stellar points will swarm in a spectacular fashion.

These two globulars reside in our Galaxy's outer halo, but several bright and easily observed clusters — the *galactic* or *open* star clusters — lie closer to home. One of the finest examples of this class of sky object — a class that includes the Pleiades and Hyades clusters in Taurus — is Messier 11 in northern Scutum. This is an unusually rich open cluster, with 400 stars brighter than 14th magnitude. M-11 measures some 12.5 minutes of arc across and boasts an integrated magnitude of 6.3.

Once you locate the cluster, a medium-power eyepiece will do a good job of framing it and will show off an 8th magnitude deep orange star near the group's center. M-11 is often referred to as the Wild Duck cluster because of its semi-triangular shape and "flock" of tiny suns.

As viewed from M-11, our Sun would appear as a mere 16th magnitude star, lost in a sea of brighter objects. The brighter cluster members in M-11 are very luminous — about 100 times more than the Sun, a staggering fact when you gaze at them through the eyepiece.


A.W. Steinbrecher

M-11, the Wild Duck Cluster

A second open cluster you should not miss is M-39 in northern Cygnus — a galactic grouping perfect for binocular devotees because of its great sparseness. This group's 30-odd stars spread over a seven light-year diameter that measures 39 arc-minutes in photographs. It lies 800 light-years away.

Use binoculars or a low-power, wide-field ocular when observing it. High magnifications actually decrease the beauty of this cluster, because they constrict your field of view. This may account for M-39's lack of popularity with owners of large scopes.

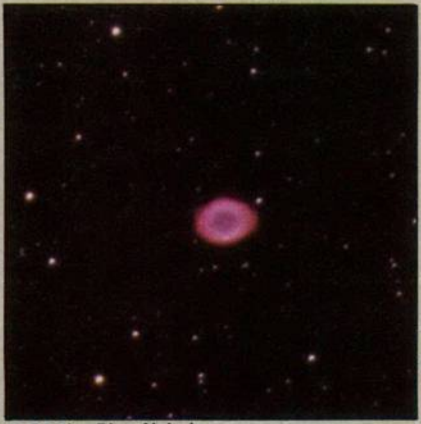
Midnight

Now that we've observed nebulae and clusters in the evening hours, let's turn toward two double stars, and begin with one you may already know.

Albireo (Beta [β] Cygni), the star at the nose of the Swan, is certainly the favorite double star of many deep-sky watchers. Its delicate gold and blue contrast never fails to impress and the pair is wide enough to be separated in good binoculars. The 3rd magnitude yellow primary and 5th magnitude blue secondary are divided by a 34 arc-second gap — which represents some 400 billion miles of space.

Swing your scope toward Andromeda to glimpse the second star, Gamma (γ) Andromedae. This is another very impressive double that has a somewhat closer angular separation. Also known as Almach, this double consists of a 2nd magnitude orange-yellow primary paired with a 5th magnitude bluish companion.

Low powers do quite well for Albireo, but switch to medium magnifications for Almach. Keep in mind that very high magnifications will hinder seeing the subtle colors of the stars. The distance to Almach is approximately 260 light-years, and the actual distance between the two stars is around 74 billion miles.


Jack Newton

M-57, the Ring Nebula

Around midnight, two of the finest planetary nebulae are well up in the sky. Messier 57, the Ring Nebula in Lyra, is one of the most observed sights outside the solar system and is often the first nebulosity picked up by beginners.

To find M-57, swing your scope midway between Beta and Gamma Lyrae and use a high-power, short focal-length ocular. Focus carefully on a starfield first to make locating M-57 easier. You'll see that the object retains its outstanding appearance even with high powers — because of its relatively high surface brightness.

M-57 appears radically different depending on what telescope and magnification you use. Scopes with less than six inches of aperture show this object as a rather dim blur. Larger instruments reveal the ring-shape of the object. Further details — including an oval shape and slight dimming at the ends of the long axis — are visible in the largest scopes. The view of M-57 through a small scope suggests why it and others of its class picked up the misleading name planetary nebulae.

Controversy surrounds sightings of M-57's central illuminating star. Some observers claim to have seen it with their 8-inch scopes, though many cannot find it in 20" or even 30" instruments. My only view of this 15th magnitude bluish dwarf came while using a 24-inch reflector. Someone has suggested that this star may be a variable. If that's true, it could explain some of the confusion.

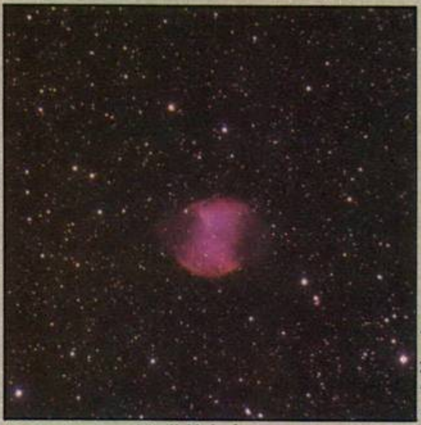
The ring is actually a roughly spherical shell of gas; it appears as a ring merely because we see more glowing gas at the edges of the shell than though the middle. Long exposure photographs with large telescopes show that the dark hole in the center of the ring is filled with elusive, faint gas. Like the Lagoon and Trifid Nebulae, planetaries are emission objects that shine by fluorescence. Astronomers think M-57 lies at a distance of 1800 light-years — which would make the true diameter of the nebula about half a light-year.

Messier 27, the Dumbbell Nebula, is another bright, well-observed planetary that is readily visible in small telescopes. M-27 lies to the south of Cygnus in Vulpecula and can be found easily by star-hopping southeast from Albireo using a star chart.

The Dumbbell measures a rather wide 6 by 8 arc-minutes compared to M-57's 1 by 1.5 arc-minute size; thus it appears somewhat more obvious in the eyepiece, even without a surface brightness as impressive as M-57's. When you observe M-27, you'll understand the reason behind its nickname — it has two lobes that form a barbell or dumbbell shape.

Although low powers show the Dumbbell adequately, slightly higher magnification with the accompanying smaller field of view increases the contrast between sky background and subtle nebulosity. Keep this in mind when you observe other nebulosities of low surface brightness.

Large scopes reveal startling structure in M-27 plus several dim stars shining through the nebula. The central illuminating star is relatively bright (magnitude 13.4), but is easily lost in the haze of the gas. The Dumbbell lies at a distance of 900 light-years and has an actual diameter of about three light-years — rather large for a planetary.


Jack Newton

M-27, the Dumbbell Nebula

Deep-Sky Monthly

If this article has piqued your interest in deep-sky observing, you may enjoy the 16-page monthly periodical for deep-sky enthusiasts. A one year subscription to *Deep-Sky Monthly* costs $9.00 U.S., $12.00 elsewhere. Write to: *Deep-Sky Monthly*, 104 Oakhill Drive, Oxford, OH 45056.

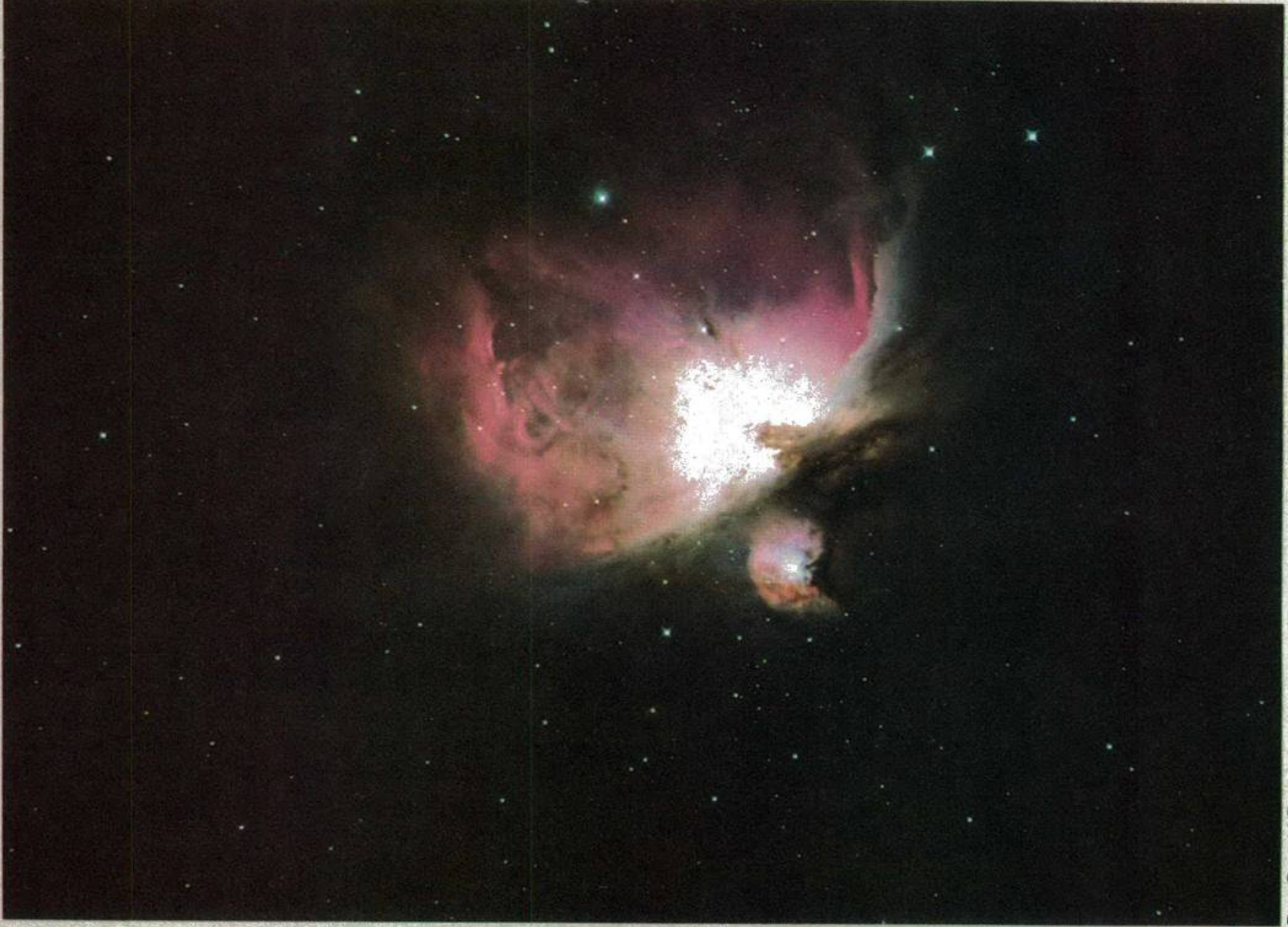
We've almost finished with the midnight group of objects. By now it's perhaps 12:30 or 1:00 a.m. local time, and the renowned Pleiades star cluster (Messier 45) awaits us. For northern hemisphere observers, M-45 ranks with the Hyades star cluster, also in Taurus, as the most obvious of deep-sky objects. The Pleiades cluster is a guaranteed crowd-pleaser, a deep-sky wonder astounding even to the naked eye. Small telescope owners never long for more aperture when eyeing this group. In fact, large scope owners turn to their finder-scopes to gaze at the group. Whatever instrument you use, make sure it has a very wide field — the cluster spreads a full 2° across.

Specialized observing of M-45 — spotting the faint reflection nebulosity around Merope, for example — requires different tactics. Use a medium to large instument, moderate power eyepieces, and hope for a very dark and transparent sky.

M-45 consists of some 250 stars that yield a combined magnitude of 1.4. It lies only 2.5 million astronomical units from us — about 30,000 solar system diameters — and is one of our nearest neighbors as open clusters go.

Rounding out our midnight group is the bright, somewhat neglected spiral galaxy in Sculptor, NGC-253. This neglect partially results from its southerly declination (-25°), which makes most observers contend with light pollution and atmospheric disturbances near the horizon. Nevertheless, it is impressive — possibly the best galaxy in northern skies aside from M-31 in Andromeda.

Lying some 8 million light-years away and 7.5° south of the bright star Beta (β) Ceti, this type Sc spiral galaxy is best observed with low to medium powers. It measures some 24 arc-minutes across and we observe it nearly edge-on. Small telescopes show a 7th magnitude, elongated streak with little detail. Larger apertures reveal slightly more — a mottled appearance and a nucleus with a somewhat stellar appearance.



M-42, the Orion Nebula

Rev. Ronald Royer

Early Morning

As the sky creeps westward and dawn approaches, we'll start our final observing stint with a bang: Messier 42, the great nebula in Orion. This is undoubtedly the finest emission nebula in the sky. Its brightness (magnitude 3) and large dimensions (60 x 85 arc-minutes) make it visible to the naked eye. It's also an impressive sight through binoculars and small finder-scopes, and a different but always beautiful sight through telescopes of varying apertures.

Start in on M-42 with the widest field of view you can muster — you'll see a large, wispy greenish-white nebulosity. Under very dark skies, it may virtually fill the entire field. To increase background contrast, try higher powers and sweep slowly and steadily around the nebula to check out its full extent.

NGC-253 in Sculptor

Greg Griffith

Zero in on the center. Near the dark bay known as the "shark mouth," you'll notice the Trapezium, a group of four stars ranging in brightness from magnitude 5.5 to 8. Many other stars — condensed out of the nebular gas — also litter the field. In all, 300 stars are packed within a 5 arc-minute diameter surrounding the Trapezium.

Messier 43, the detached nebula slightly north of the main body of M-42, is also easy to see. Shining at magnitude 9, it forms a bloated comma in large scopes, with an 8th magnitude star included. As with the eastern and western edges of M-42, sharply-defined bright areas of nebulosity fan outward and south of the nebula.

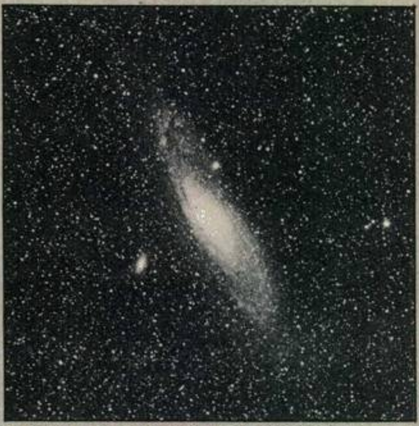
In long-exposure photos, the whole Orion region is enveloped in a blanket of nebulosity. M-42, like M-8, shines brightly due to hot O and B-type stars which emit ultraviolet radiation that charges the gas particles and makes them glow. M-42 is about 60% hydrogen and 38% helium; the remaining 2% is carbon, oxygen, nitrogen, and several other elements.

M-1, the Crab Nebula

Bill Iburg

Keep your low-power eyepiece attached and swing your scope toward the great galaxy in Andromeda (M-31) for a remarkable view. M-31 is the closest spiral galaxy outside our own and can be seen with the naked eye as a diffuse glow on dark nights. Peering into the ocular, you won't see the full extent of its spiral arms (which measure 50 x 158 arc-minutes), but you will see a 5th magnitude pale yellow nuclear region and perhaps traces of faint twirling arms.

As with M-42, medium powers and slow field-sweeping will reveal additional detail in the galaxy's outer regions. On good nights — with a


David Healy

M-31, the Great Galaxy in Andromeda

medium to large scope — dark lanes consisting of interstellar dust, a tiny almost stellar nucleus, star cloud NGC-206, and several degrees of faint nebulosity will be visible. The outer nebular regions are very difficult to discern; the arms may appear as a subtle change in the sky background. Companion galaxies M-32 and NGC-205 are an added attraction that shine at magnitudes 9.5 and 11 respectively.

Messier 32 measures 3 x 3.5 minutes of arc in diameter, lies close to M-31's nuclear region, and is usually visible as a relatively bright circular patch of haze. NGC-205, northwest of M-31's nucleus, is somewhat larger, at 3 x 8 arc-minutes, but appears dimmer and much hazier.

In addition to its beauty, the Andromeda Galaxy is of great importance in the history of astrophysics. It was within this object in 1923 that Edwin Hubble detected Cepheid variable stars which helped him postulate the first reliable distance determination to a galaxy. In part, this resolved the debate concerning the "spiral nebulae." These were correctly identified as huge systems as large as our own Galaxy and demonstated the true scale of the universe for the first time.

The distance to the M-31 system — itself a part of our Local Group — is 2.2 million light-years. Similar in many ways to our Milky Way Galaxy, it measures 110,000 light-years across and contains 300 billion stars. M-31's central hub rotates once in about 11 million years.

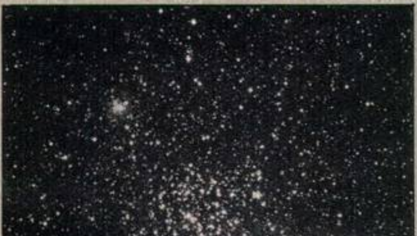
Our next object, the 5th magnitude open cluster M-35 in Gemini, is favorably located for observing during early mornings in September. This huge gathering of suns — half a degree across — requires long focal-length eyepieces that yield wide fields of view. After centering your finder on the group, the field will be filled with bright, scattered stars. Some 120, ranging from 8th to 13th magnitude, make up the cluster.

High power tends to reduce M-35's beauty, but is fine for views of the nearby "companion" cluster NGC-2158, which lies 30 arc-minutes southwest of M-35's center. NGC-2158 is one of the richest of all open clusters — it measures only 4 minutes of arc across, but packs in 40 stars. At magnitude 12, it's a difficult target for small scopes, but is fantastic through medium and large apertures. NGC-2158 lies an astounding 16,000 light-years away, while M-35 is only 2200 light-years distant. The two are completely unrelated physically and only lie close together in the sky from our vantage point.

Another great cluster, the globular M-79, lies below Orion in the small constellation Lepus. Messier 79 is not particularly large, nor is it a prime example of a globular, yet it provides stunning views on dark nights. Once you've located it, switch to medium or high powers (around 20x per inch of aperture) and focus sharply. This 8th magnitude group of 90,000 suns starts to resolve around its perimeter in 8-inch or larger scopes; its brightest stars are 14th magnitude.

Galaxy M-33, well above the eastern horizon at early morning hours, is often described as hard for small telescope users to locate, but it really isn't — provided you start with good skies. A wide-field eyepiece is absolutely essential due to the galaxy's size (38 by 62 minutes of arc). M-33 has a very low surface brightness, so its textbook magnitude value of 5.3 is pretty misleading when you search for it.

Look for a large, rather dim oval mass. If you have a large scope, you'll pick up patches of brightening, knotty structures (star clouds), and even spiral arms. Sweep the field to pick out fainter details, and make sure your eye is adequately dark-adapted. Under dark, steady skies, M-33 is a fine binocular object and is even faintly visible to the naked eye.


Robert Provin

M-35 and NGC-2158 in Gemini

The distance to this fellow Local Group member is around 2.4 million light-years, slightly farther than M-31. Astronomers estimate that M-33 measures some 60,000 light-years across. M-33 may not be one of your instant favorites, but given time it will grow on you.

Perhaps it is fitting that we finish our survey with the one deep-sky object that, two centuries ago, inspired French comet-hunter Charles Messier to begin the catalog that has inspired many observers to seek out deep-sky splendors: Messier 1, the Crab Nebula. M-1 began its life 900 years ago when a star died in a supernova explosion. M-1 is also the prime example among a small handful of observable supernova remnants.

Photographs of this object taken years apart show a slight expansion in the tendrils of gas that conceal the 16th magnitude star left after the explosion — the first pulsar to be discovered. Incredibly, the gas composing the Crab Nebula is traveling outward at a rate of 600 miles per second. Only the nebula's distance of 6300 light-years makes its expansion appear slight.

Observationally, M-1 is a delight, but you won't see any of the filamentary structure visible in observatory photos. The nebulosity takes high powers fairly well, so after you locate it, crank up the magnification a bit. But don't go beyond the limit imposed by seeing conditions.

A small (4 by 6 arc-minute) oval nebulosity is easily visible even in very small scopes, and large apertures reveal slightly more of the shape. The Crab shines at magntude 8.5 and will surely captivate you even at the tail-end of a long night of observing.

Well, you're now among the ranks of deep-sky observers. You've spent a full evening pursuing and perusing a wide variety of deep-sky splendors; what do you think? Have you picked up some of the flavor of the game that keep old timers' energy and enthusiasm high?

Remarkable improvements in instrument design and use appear regularly; the "Dobsonian revolution" has just begun to change amateur astronomy by providing large telescopes at small prices. At least two national societies are involved with deep-sky observing (one in the U.S., the other in the U.K.), and there's even a magazine on deep-sky observing (see box).

These observing aids and improvements in design will surely create a tremendous surge of popularity in deep-sky observing.

Why not join the fun?

David Eicher is an astronomy student at Miami University in Ohio. He has been an observer since he was 15 years old and has published **Deep-Sky Monthly** since 1977.

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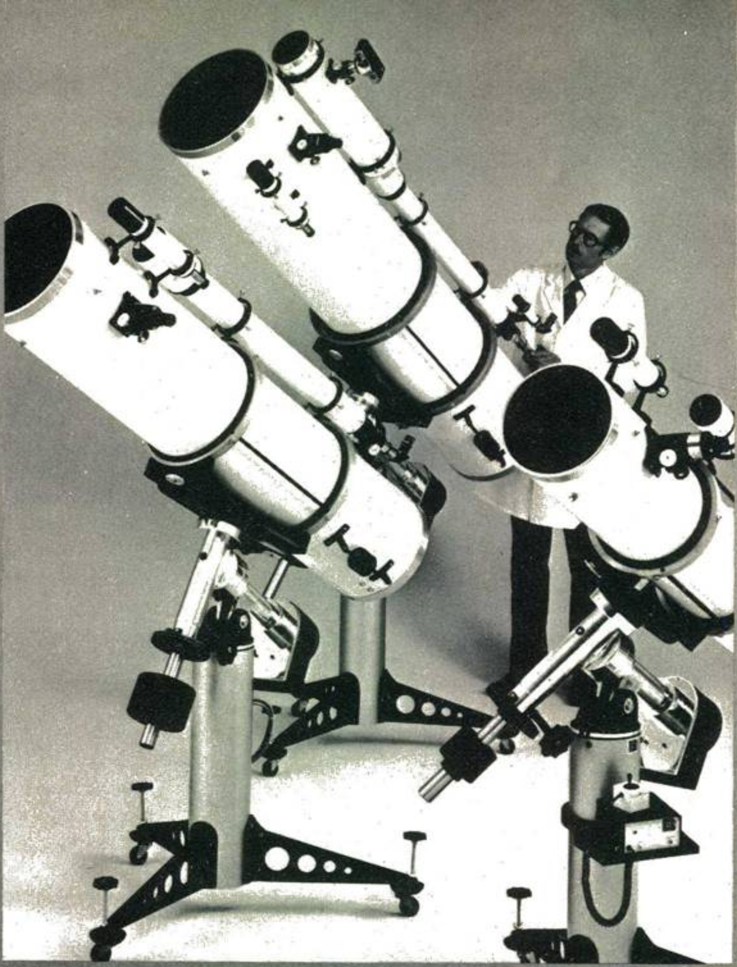

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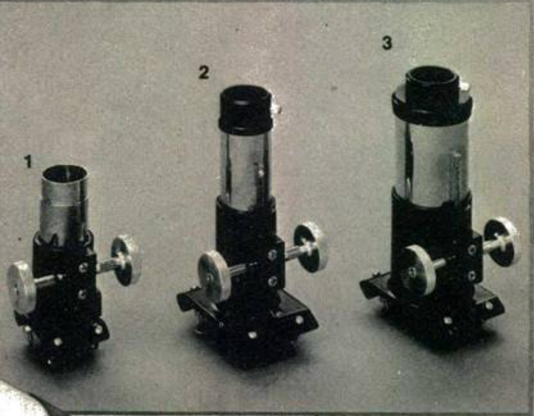

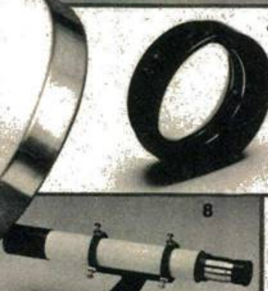

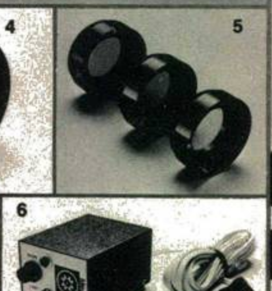

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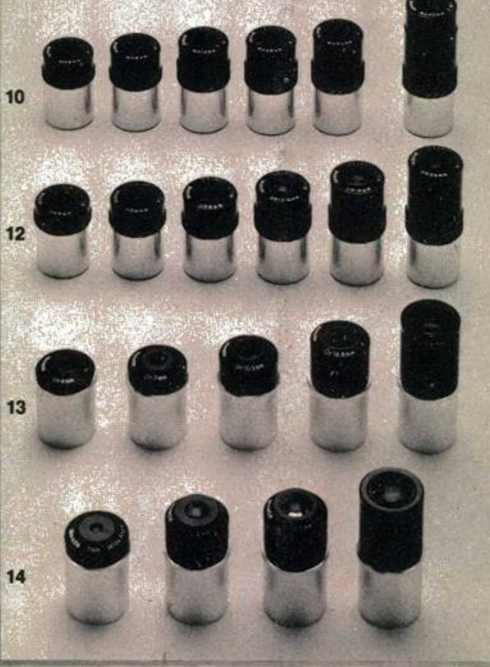

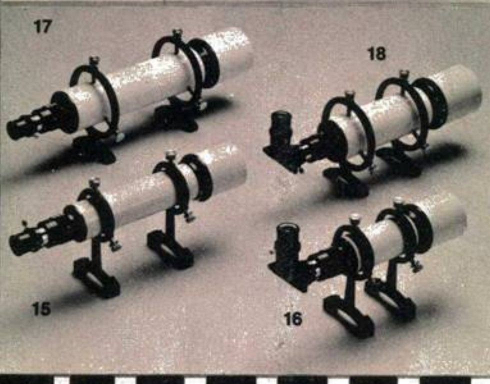

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This instrument is the only telephoto lens offered by Celestron of other manufacture. The unit is imported to exacting specifications for us.

Included in the base price are lens caps, carrying case, and ND2 filter (34mm).

BASIC 300mm SPECIFICATIONS

Optical configuration	catadioptric
Clear aperture	2.4 in. (65mm)
Effective focal length	11.8 in. (300mm)
Photographic speed (focal ratio)	f/5.6
Near focus (approx.)	8 ft. (2.4mm)
Image scale (degrees per inch)	4.9
Film coverage (on 35mm format) at:	
30 ft.	2.8 x 2.2 ft. (.85 x .67m)
100 ft.	9.4 x 7.5 ft. (2.8 x 2.3m)
1000 ft.	94 x 75 ft. (28 x 23m)
Tube dimensions	2.56 in. (65mm) long x 2.75 in. (70mm) wide
Tube weight	9 oz. (0.26 Kg.)
Shipping weight	15 oz. (0.42 Kg.)

SEE OPERATING MANUAL FOR COMPLETE SPECIFICATIONS.

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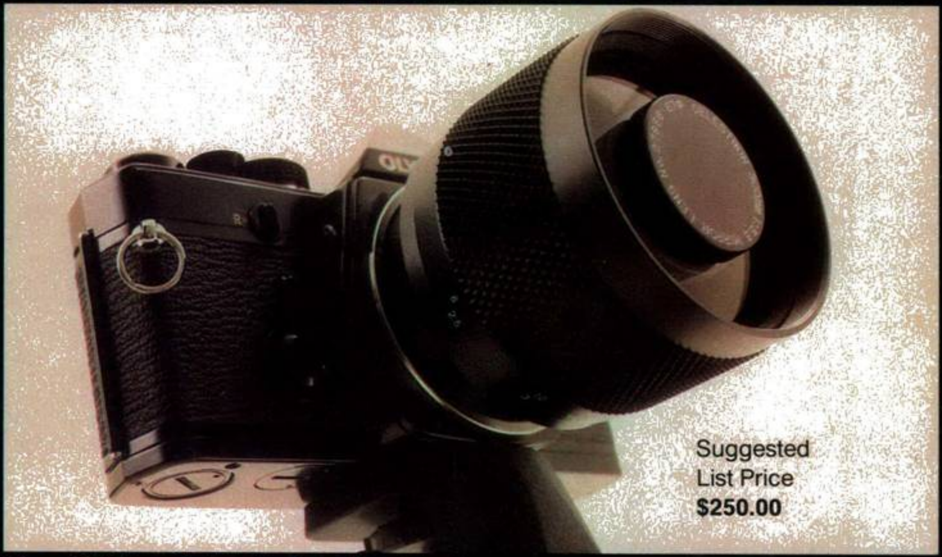

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300mm f/5.6 Telephoto Lens Used on a Photo Tripod

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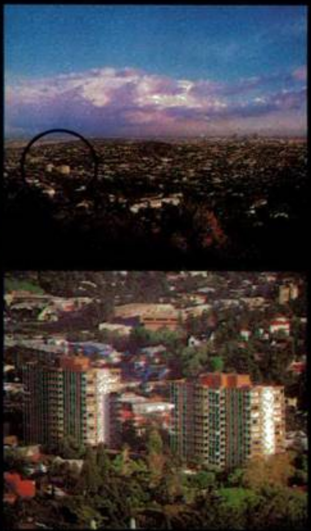
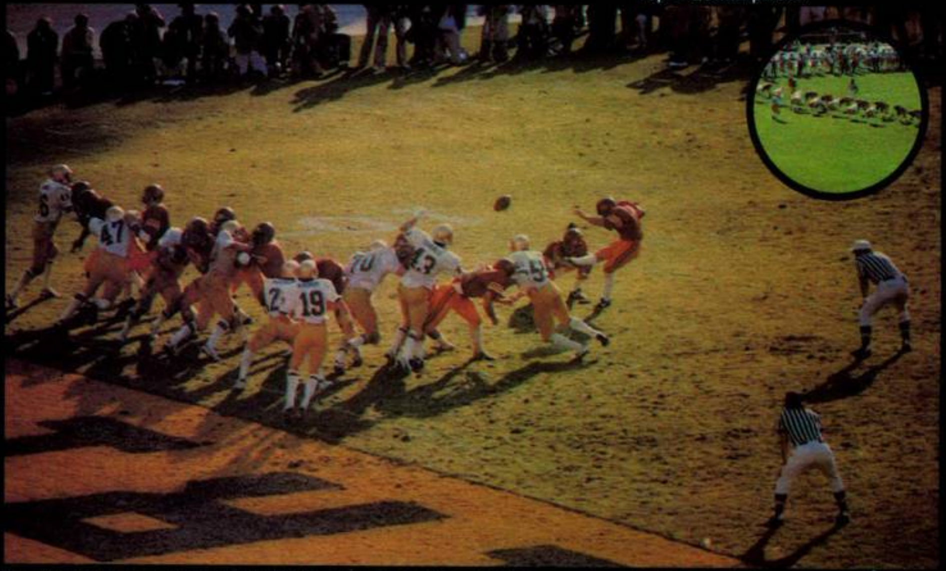


Long Distance Photography—
Top — 28mm photo



Sports Actions — Traditional USC vs Notre Dame Football Game — Inset — 50mm photo

SEE BACK COVER FOR CATALOG INFORMATION

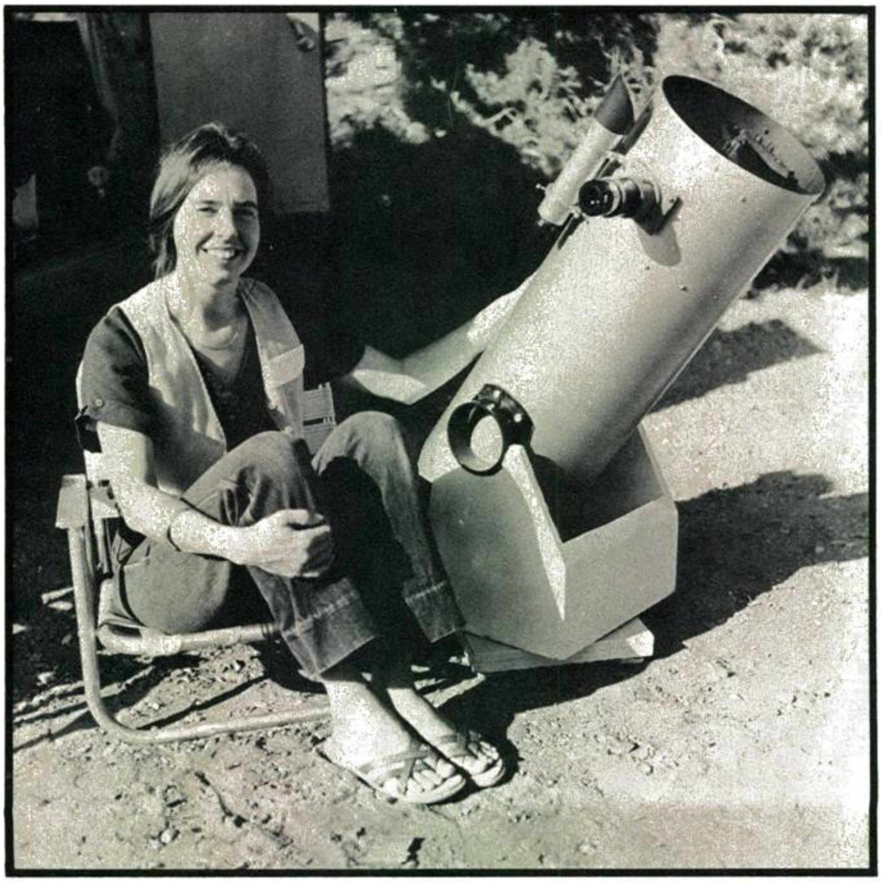
equipment atlas

handcrafted homebuilt telescopes

On Memorial Day weekend, roughly one thousand amateur telescope makers converged on a campground near Big Bear City in the San Bernardino Mountains of southern California. The attraction was the Riverside Telescope Makers Conference, an annual event jointly sponsored by the Riverside and San Bernardino Astronomical Societies.

The event has an air of festival about it. All weekend long, people talk telescopes and share their love of astronomy.

The Riverside meeting has become the watershed for both hobby and commercial trends in telescope building. There, one can sense the ways in which the hobby is growing. For many years, telescope builders have been the pacesetters, pressing not only their friends but also the telescope making industry toward more sophisticated instruments. This year, however, the emphasis began to shift, not so much away from "high-tech" telescopes, as toward an appreciation for "handcrafted" ones. Of the Merit Awards given this year, over half were for telescopes constructed largely from wood. Telescope builders have long recognized the superb qualities of wood, but never before have so many used it.

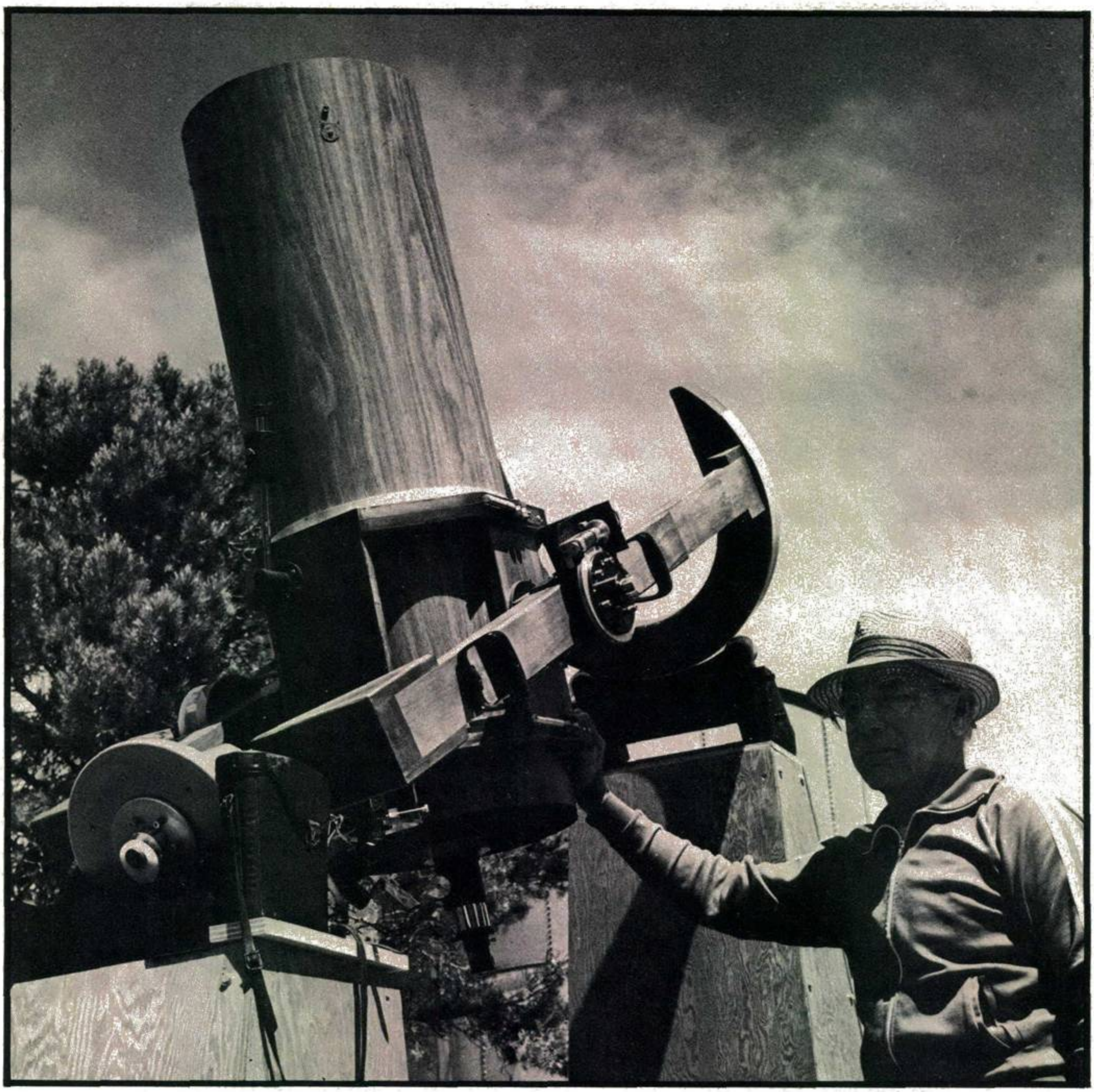


With the steady spread of light pollution and the increasing number of small cars, telescope portability has become more important. The workbench crafters of telescopes have kept pushing down the focal ratio, and hence the overall length of the tube. Although the practical lower limit of Newtonian focal ratios lies somewhere around f/4 or f/5, today's builders work right to that limit.

Another trend is toward deep-sky observation with large, short-focus Newtonian telescopes. The Dobsonian, a sturdy alt-azimuth design, has exploded into sudden prominence. Of the telescopes with apertures 16" or more at Riverside 1981, more than half were Dobsonians. And most of the remaining equatorially-mounted large telescopes were fast Newtonians.

One of the most delightful "small" telescopes was Stephanie and John Mood's 10-inch f/4 Newtonian on a Dobsonian mount. It stands only about three feet tall, and could be easily carried in the back seat of a small car — or even the passenger seat of a tiny sportscar. The mounting, a little over a foot high, supports the telescope on two plastic plumbing fittings bolted to the sides. The telescope moves smoothly around and up and down — so smoothly that it seems to float. You just push it to point it. Here is a telescope that can be — and is — used while sitting in a lawn chair, yet it has the full light-gathering power of a 10" aperture.

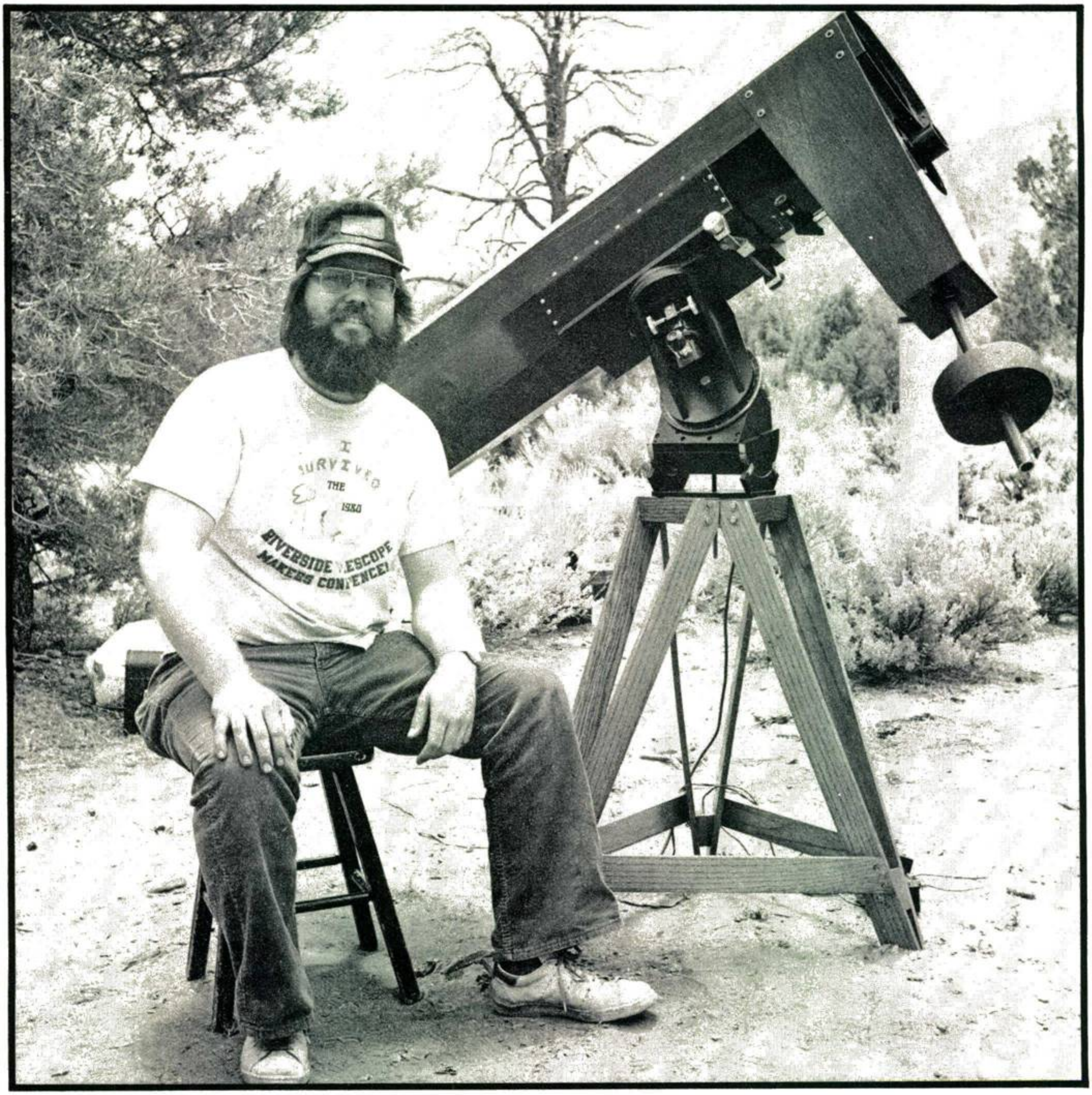
Not really portable at all, but a fine and practical telescope, is Larry Stancil's 12-inch Cassegrain in a horseshoe-yoke mount. Like the 5-meter Palomar Mountain telescope, this telescope benefits from the stability inherent in the two-pier yoke design. Unlike the Palomar telescope,

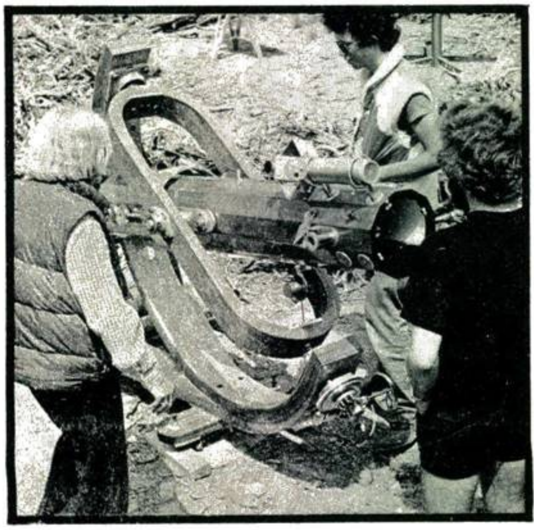


this one rides in a wooden yoke, made of beautifully-finished birch. "Birch is very rigid and it damps fast," said the builder, "besides, it's easier to work than metal." The horseshoe, which permits the scope to be pointed at the pole, is made from four layers of ½" plywood glued together and then cut to shape with a router. An aluminum strip ⅛" thick wrapped around the yoke and screwed down provides a good rolling surface. The tube, though it looks like wood, is made of wood-grained formica rolled into a tube. For its Riverside appearance, the telescope was mounted on two temporary piers made of ½" plywood. Normally it rides atop two concrete piers.

At still another extreme was the

Opposite page: John and Stephanie Mood's 10-inch f/4 super compact Dobsonian RFT. Above and right: Larry Stancil's wooden yoke mount supports a 12-inch Cassegrain very solidly. The horseshoe-shaped north bearing turns on rollers.

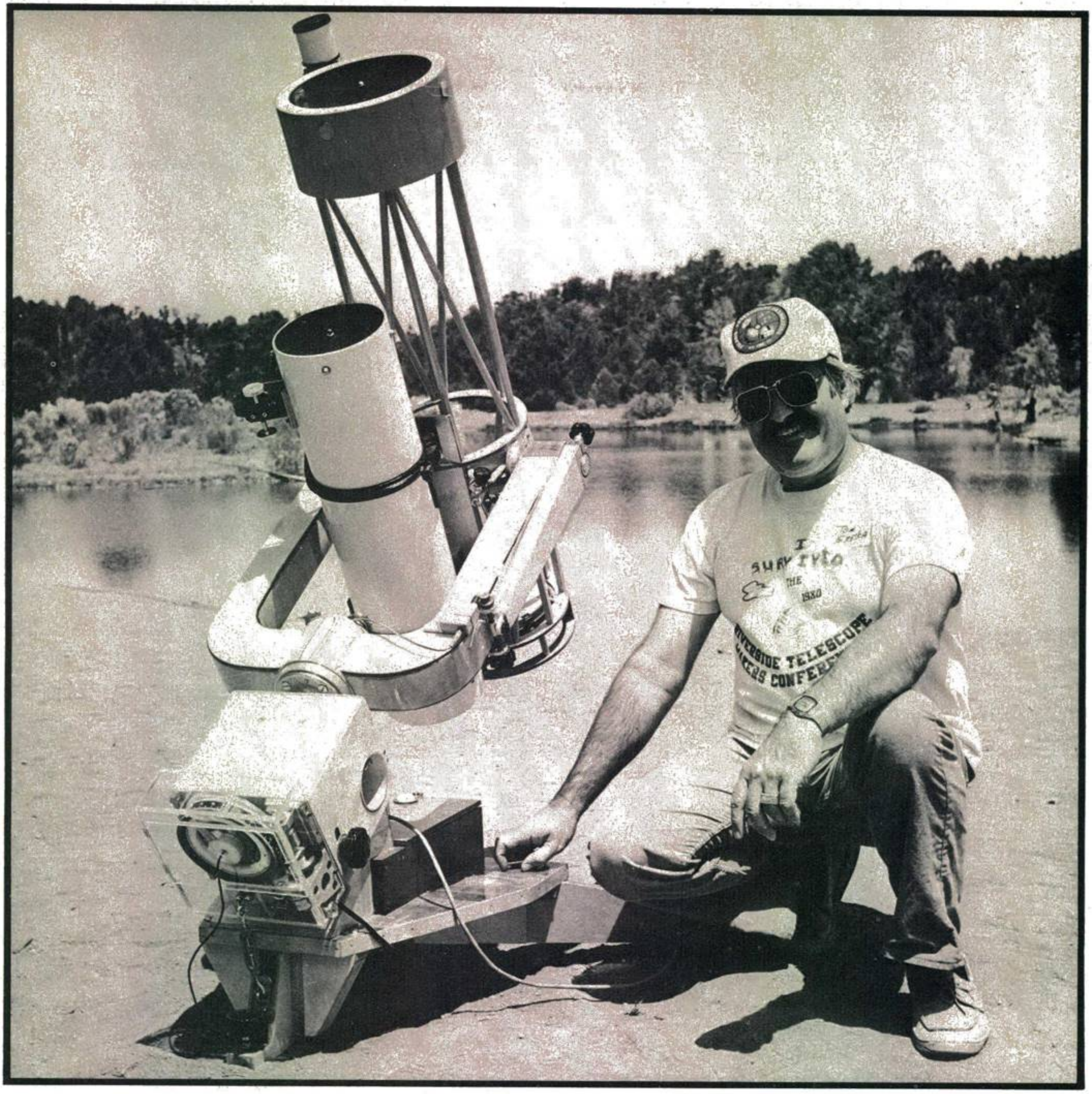




Left: Weyman Reams's 8-inch Newtonian is a work of art. Above: Tim Parker's Springfield telescope has a stationary eyepiece — no matter where the telescope is aimed, the eyepiece remains at the intersection of the declination and RA axes. Opposite page: Tom Greska spent hundreds of hours building his fork-mounted 8-inch Newtonian.

massively constructed 8-inch f/8.3 Newtonian in a laminated wood yoke mount crafted by Weyman Reams. Clearly the result of years of work, this telescope is built like a piece of fine modern furniture. The telescope's tube, twelve-sided, is made of mahogany stained and finished to a high shine. All major structural parts of the mount are heavy sections of laminated wood, curving in graceful arcs. Attached at the crucial bearing points are machined parts — some chrome-plated — that give the instrument a very modern look.

For sheer comfort and convenience in observing, nothing can beat a Springfield mounting. With a Springfield, the eyepiece always stays

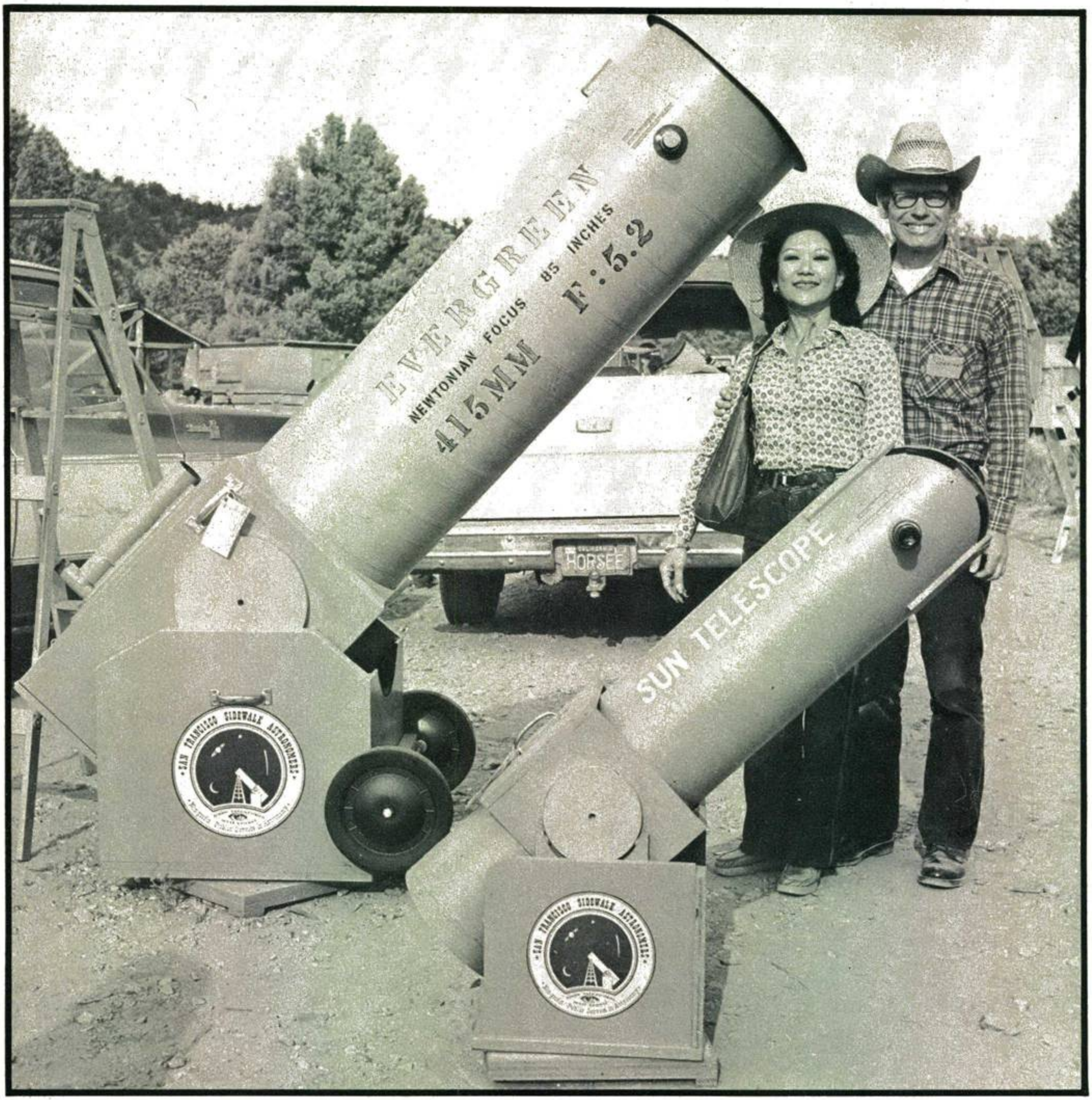


in the same place. Yet we don't see them very often, and we seldom see one as fine as the one Tim Parker showed this year at Riverside. He constructed the nine-sided tube from ¼" thick Indian rosewood veneered plywood, and added internal bulkheads and fiberglass in some places for strength. The tube rests in an aluminum saddle carried on a professional-looking mount. Tim shaped the pieces from ½" aluminum plate with a bandsaw and put in the holes with a drill press, but he used hand tools for the rest of the work — with a few exceptions on the drive. The tripod is also wooden — and amazingly solid. Since the eyepiece of this 8" f/6.3 instrument always remains stationary, the observer — with both controls and finder within easy reach — can sit comfortably on a chair and look through the scope.

A very different approach to a telescope mounting, but one that also employs wood, was taken by Tom Greska. Built from dowels and thin aircraft-grade birch plywood, it exploits to the utmost the light and rigid qualities of wood. And this telescope is really solid; in fact, it is used for deep-sky astrophotography through a second telescope attached to the main 8" f/6 instrument. Although the materials were rather expensive (about $650) and construction time rather long (350 hours), its builder clearly feels it was worth all the effort.

In contrast to the wooden telescopes finished to show natural wood grain, Bill and Edwina Cherrington's 16-inch Dobsonian was painted bright green. Why? To attract attention, of course, because their telescope is one of the San Franscisco Sidewalk Astronomers telescopes frequently used out on the streets for public viewing. The 16-incher, named *Evergreen*, fits in the back of a station wagon. The tube is painted Sonotube, the entire mount is ordinary fir plywood, the mirror is handmade from 1" plate glass. Incidentally, it gives an excellent image.

Finally, we must never assume that good craftsmanship involves only wood. Fine work may involve any and all materials. Shown in close-up is part of the telescope used by astrophoto-



Above: Bill and Edwina Cherrington stand beside their 16-inch Dobsonian reflectors. To make the Sun safe for viewing, the telescope in front uses a reflective filter to reject 99% of the incoming light. The uncoated primary mirror and an absorbing filter remove still more light. Left: Orien Ernest's guide telescope.

grapher Orien Ernest to guide exposures with his 8-inch f/5 Newtonian. Bits of aluminum and brass, scrap hardware, army surplus, and junk-bin materials have been welded, filed, and turned to produce a functional — yet sculptural — instrument. Orien has taken the trouble to smooth all the corners, round all the ends, and knurl all the knobs.

In a world of mass-produced goods, the urge to do something of your own — something finer and better and more beautiful — ultimately asserts itself. As astronomy moves into the 1980s, with every indication of becoming an increasingly popular pastime, handcrafted telescopes are here to stay.

— *Richard Berry*

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As you can see from the attached list of eyepieces that I have owned over the last 5 years and now own, I have rejected more than I've kept (this includes one 2-inch $200 eyepiece that many experts had said was the very best available). I can tell you with assurance that my new TELE VUE Plössls will never appear on my list of rejected eyepieces!

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Yours most sincerely

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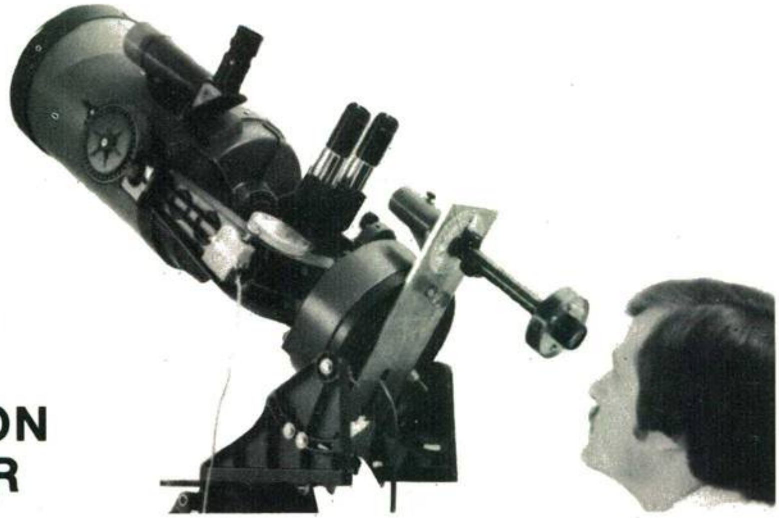

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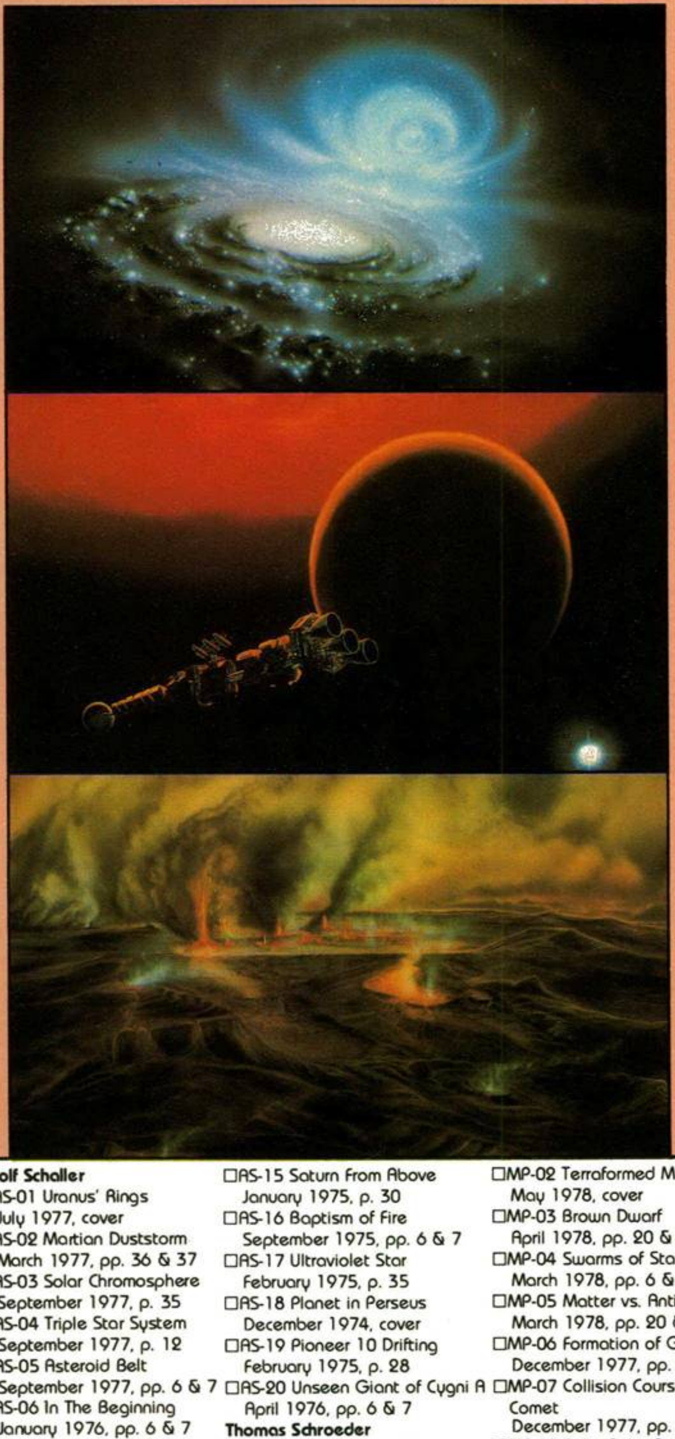

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AstroNews

Alpha Ceti Spews High-Power Radio Flare

Scientists have long known that the Sun, a rather normal, middle-aged star, occasionally acts more like a Mr. Hyde than a Dr. Jekyll. Sporadic solar storms produce flares of violent hot plasma that dwarf the Earth. These flares wreak havoc with terrestrial radio communications, and make our ionosphere opaque to high frequency radio signals. But flares also put on their own radio shows at still higher frequencies — raw noise given off by relativistic electrons as they spiral along solar magnetic field lines.

For decades astronomers have monitored flares to figure out how solar storms work and have wondered if flares occur on other stars. In the past, radio activity similar to that on the Sun has been detected in binary systems such as the RS Canum Venaticorum stars, and volatile dwarfs like the UV Ceti stars.

But now a new radio flare star, believed to be otherwise normal, has been discovered, which suggests that radio flares may be characteristic of other stellar types.

The star is Alpha (α) Ceti, the brightest star in Cetus. It is a late-type giant: a huge, cool (2500° Kelvin) red star. As red stars go, it's a mundane object, having no detectable pulsation in its atmosphere, no companion stars, and no shrouding nebula of dust or gas. It came as a real surprise to astronomers that such a normal star could flare.

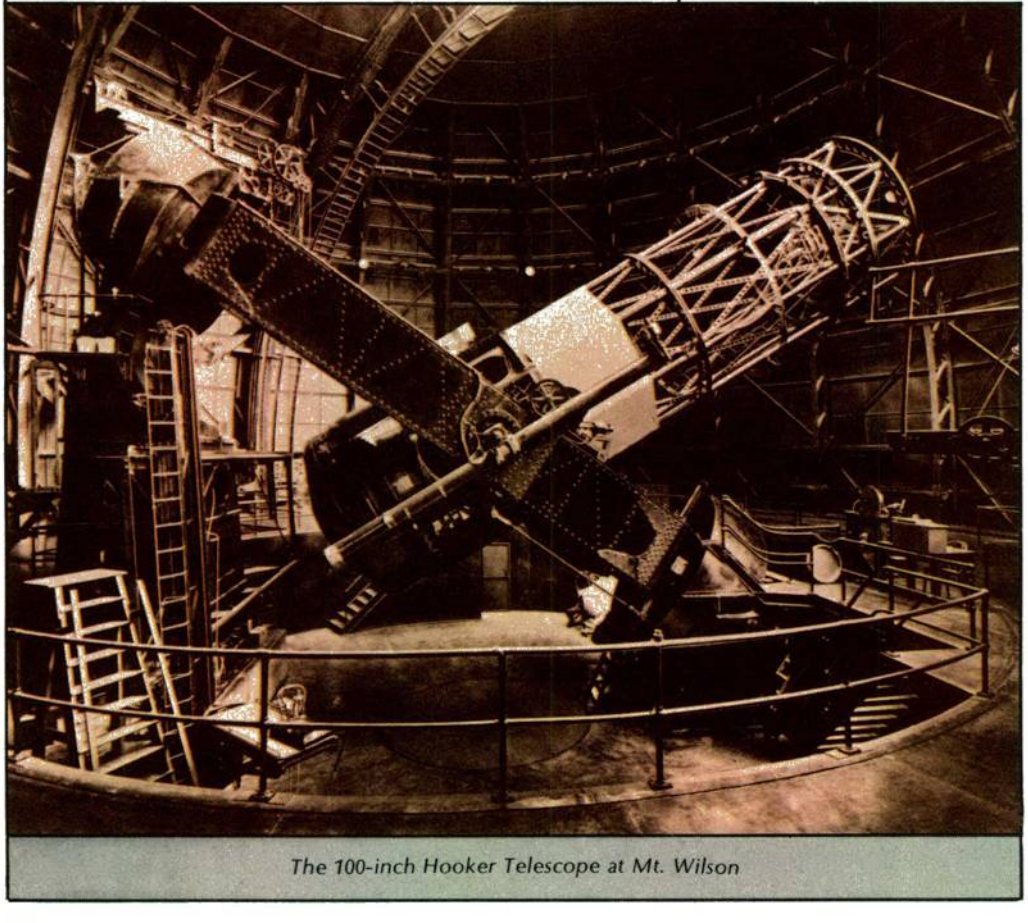
New Mexico University astronomer Daniel Boice and his colleagues reported the discovery in a recent issue of *Astrophysical Journal Letters.* Using the Arecibo (Puerto Rico) Observatory's 1000 foot radio telescope, they observed 15 late-type red giant stars at a frequency (430 mHz) that is near UHF television channels. During the six-day-long observing session — which was plagued by radio interference from terrestrial stations — only scattered fractions of the time were useful for astronomy. But Boice and his coworkers were lucky; during one of the times when the intereference disappeared, they detected a fleeting radio flare in Alpha Ceti.

The 30-second flare was long enough to be noticed, though not long enough to provide much information. But it was remarkable for such a star — as if the largest solar flare were scaled up ten million times in energy, and spewed out of an area only 1/300th the star's surface.

What happened? Astronomers will have to make many additional observations before they can begin to know why — momentarily — Alpha Ceti loses its cool. *N.L. Cohen.*

Hooker Telescope Named International Landmark

The American Society of Mechanical Engineers (ASME) has designated the 100-inch Hooker Telescope at Mount Wilson, California, as an International Historic Mechanical Engineering Landmark. The Hooker Telescope, completed in 1918, was for three decades the world's largest; its use made possible some of the most significant research in modern cosmology including the discovery of the expanding universe.



The 100-inch Hooker Telescope at Mt. Wilson

The telescope will be the fourth international landmark in the U.S.A. and the second in California dedicated by ASME. Since 1973, 59 landmarks have been designated including the Pike's Peak Cog Railway in Colorado, and the Saturn V Rocket, Cape Kennedy, Florida.

The purpose of the ASME Landmark Program is to identify mechanical engineering works of national and international importance, to increase public awareness of mechanical engineering contributions to progress and development, and to preserve the physical remains of such sites.

George Ellery Hale, founder and first director of the Carnegie Institution of Washington's Mount Wilson Observatory, was the prime force behind construction of the large scope. Even before completion of the 60-inch reflector at Mount Wilson in 1908, Hale was planning for the Hooker project.

A Los Angeles businessman,

John D. Hooker, provided funds for casting the 4.5-ton glass disk for the great mirror. In 1911 Andrew Carnegie made his second major endowment to the Carnegie Institution, which made possible the construction of the mounting and dome. The six-year task of grinding and polishing the disk was performed in Pasadena.

On November 2, 1917, Dr. Hale made the first test observations with the 100-inch instrument and learned that all major mechanical and optical problems had been solved. The new telescope collected three times as much light as the 60-inch, and it could thus record stars one magnitude fainter than any seen with the 60-inch. Its resolving power was correspondingly superior.

The scientific importance of the 100-inch instrument was soon verified. Astronomers had previously sighted countless "spiral nebulae" but had been unable to agree whether they were part of our Milky Way Galaxy or were themselves separate "island universes." The Hooker Telescope enabled astronomer Edwin Hubble to resolve the spiral arms of several "nebulae" into individual stars and to identify among them the Cepheid variable stars which later helped him establish that the "nebulae" were galaxies like our own Milky Way.

German Satellite Scheduled on First Operational Shuttle

NASA and Messerschmitt-Boelkow-Blohm GmbH (MBB), a West German corporation, have signed a launch services agreement for the first flight of the Shuttle Pallet Satellite (SPAS-01), which will be carried into orbit on the first Space Shuttle operational flight now scheduled for September 1982.

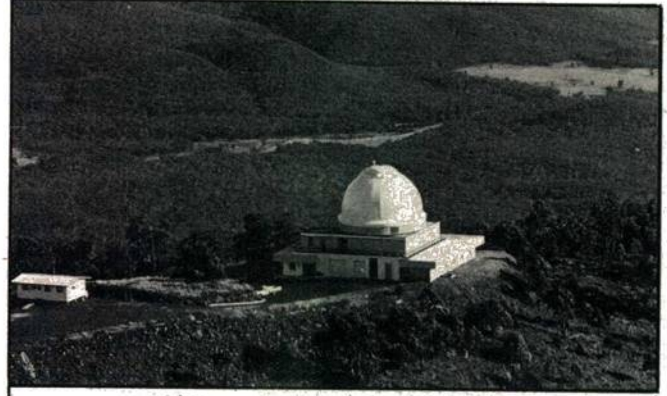
The 1,814-kilogram SPAS-01 is designed to operate inside the Shuttle payload bay and as a "free flyer" operating outside the ship. When on its own, it will be controlled by an on-board system.

MBB will use the five-day inaugural flight to conduct various materials processing research experiments from the Shuttle payload bay. NASA will use the payload to run tests on the Shuttle's Canadian-built remote manipulator arm.

Voyager Team Earns Awards for Planetary Explorations

NASA presented medals and awards to members of the Voyager project team in a ceremony held recently at the Jet Propulsion Laboratory, Pasadena, California. The awards recognized nearly 10 years of effort including early project planning, mission and spacecraft design, early flight operations, and the two highly successful encounters with Jupiter in 1979 as well as the Voyager 1 Saturn encounter in 1980.

Dr. Bruce C. Murray, JPL director; Raymond L. Heacock, former project manager; Harris M. Schurmeier, former project manager; and Dr. Edward C. Stone, project scientist, received Distinguished Service Medals for their contributions.



The UK Schmidt Telescope at Siding Spring Observatory in Eastern Australia. Photo courtesy of the Australian Information Service.

Astronomers in Australia Complete Major Sky Survey

British astronomers and technicians have completed the main part of the first major optical survey of the southern hemisphere sky using the 48-inch Schmidt Telescope at the Siding Spring Observatory in eastern Australia.

The eight-year project is a joint effort of the British Science Research Council (SRC), and the European Southern Observatory (ESO) in Chile.

The southern sky survey covers the area that cannot be seen from the northern hemisphere. More than 1000 photographic plates covering hundreds of fields of view have been exposed. About 600 will be used in the ESO/SRC *Atlas of the Southern Sky* now being printed at ESO headquarters in Munich, West Germany. When completed, the atlas will be distributed to several hundred astronomical subscribers throughout the world.

Because of improvements in the optics of the Schmidt Telescope as well as in photographic emulsions, the survey will provide plates with greater clarity, detail and resolution than a similar survey produced by the 48-inch Schmidt Telescope at Mount Palomar in the United States in the 1950s.

Terry Bransdon

Satellite Splashes Down 5½ Years / 31,000 Orbits Later

NASA's Atmosphere Explorer-5 satellite (AE-5) re-entered the Earth's atmosphere on June 10, after 31,268 orbits and more than 5.5 years of service.

The last signal was received from the spacecraft over Hawaii. Its descent trajectory took it across the Pacific Ocean, Central America, and into the Atlantic Ocean. When the sattelite was due over Ascension Island, no signal was received. NORAD later confirmed that AE-5 re-entered the atmosphere at 9:57 a.m. EDT in the Caribbean, east of Nicaragua.

The 720-kilogram satellite was launched from the Kennedy Space Center on November 20, 1975. Its technical payload consisted of 15 highly specialized scientific instruments which, during the mission's lifetime, gathered valuable data about the thermosphere and greatly expanded our knowledge of the space environment near Earth.

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AstroNews

AE-5 was the first spacecraft to use on-board propulsion to make large orbit changes, and a central computer and data base. As data were gathered by the instruments, they were immediately available to all members of the investigator team via small terminals at their own institutions.

Amateur Photometrists Meet: Set 1982 Symposia Schedule

An increasing number of amateur and professional astronomers have found they can make important contributions to astronomy through photoelectric observations of variable stars. But because stellar photometry requires specialized equipment, data analysis, and observational techniques, many potential observers have been hesitant to enter this field.

To inform and encourage these people to think otherwise, the International Amateur/Professional Photoelectric Photometry (IAPPP) held a symposium recently at the Dayton Museum of Natural History. Chaired by Dr. Douglas S. Hall from Vanderbilt University, it featured information exchanges between amateur and professional astronomers. Technical paper sessions included discussions on observing programs, observation, equipment, and observatories.

The symposium began with O. H. Brettman, president of the Astronomical League, speaking on the National Amateur Astronomical Network, a group of large telescopes soon to be made available to serious amateur observers. Next, a paper on portable photoelectric observatories was presented by H. J. Stelzer and G. Bower. Bower, a high school junior, is perhaps the youngest photometrist in the world. Four other observers gave papers on their own photoelectric observatories.

The session on observations and analysis of data began with Dr. E. P. Belserene's paper on period search techniques for micro-computers. Dr. Belserene is the director of the Maria Mitchell Observatory. G. W. Henry and Dr. D. S. Hall both spoke on the amateur-produced data that have been used to unravel the mysteries of stars with giant starspots.

The session on equipment began with a description of an easily built photometer for small telescopes, and included papers on amplifiers, high voltage power supplies, and other advances in equipment.

The last session included a review of the history of photoelectric photometry by R. Genet and comments on the future of photoelectric photometry by Dr. R. K. Honeycutt.

The next IAPPP symposia will be held in May 1982 in New Zealand, in June in Dayton, Ohio, and in Bologna, Italy next August, just prior to the IAU meeting. Write R. Genet, Fairborn Observatory, 1247 Folk Rd., Fairborn, OH 45324 for additional information.

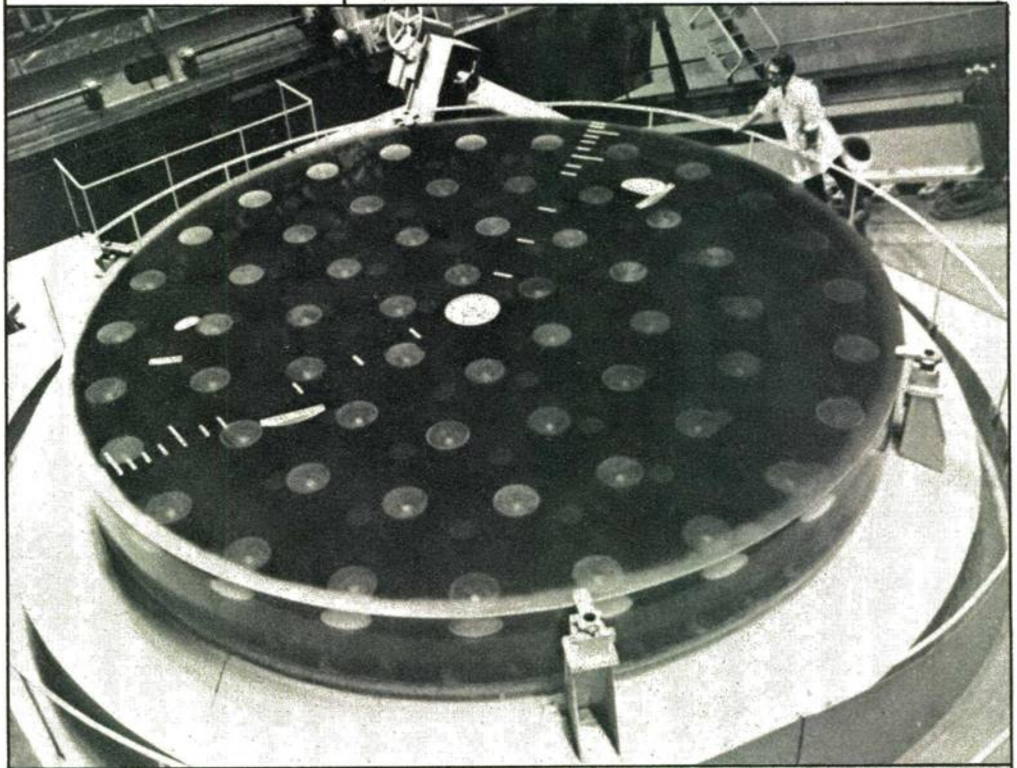
Soviets: Primary to Blame for 6-Meter Scope Problems

A candid explanation for the continuing poor performance of the world's largest optical telescope, the 6-meter scope at Mt. Zelenchukskaya in the Soviet Caucasus mountains, has been put forth by astronomer L. I. Snezhko in a recent issue of *Soviet Astronomy.*

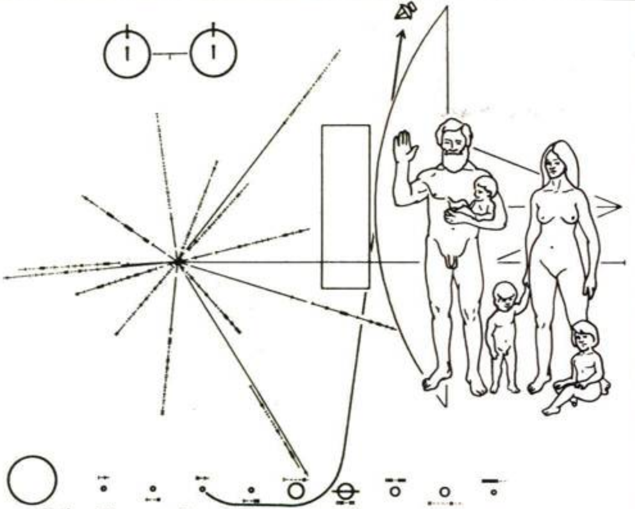
The problem lies in thermal distortions of the Pyrex primary mirror caused by night-to-night temperature changes of several degrees.

Similar temperature changes occur at Mt. Palomar, but the 5-meter mirror there is much thinner and comes to equilibrium in a few hours. By contrast, the thick Soviet mirror has such a high thermal inertia that it can take up to three days to respond to temperature changes. This also frustrates attempts to adjust the mirror's temperature during the day. The result, except for those rare occasions when atmospheric temperatures stay similar for many nights in a row, is that the 6-meter mirror is often out of shape.

The only solution, Soviet astronomers say, is to replace the Pyrex mirror with a new one of zero-expansion ceramic — a time consuming modification for a telescope that has taken 15 years to plan and build. *Ian Ridpath*



The following caption was supplied with the above photo: "The 42-ton, 28-square meter, six-meter parabolic mirror before the final control polishing at the optical factories in Leningrad. It is intended for the world's biggest BTA telescope that is to be mounted at the Zelenchuk Astrophysical Observatory in the Northern Caucasus. As one will distinctly realize, the accuracy of the observation data obtained depends on the accuracy with which the mirror is made. The permitted allowance is no more than 4/100 of a micron, which is a thousand times less than the thickness of the human hair. Furthermore, since the surface may be marred by the mirror's own weight and the slightest fluctuations in temperature, a constant temperature is maintained with an accuracy of one tenth of a degree in the enormous, isolated polishing room. The entire process of grinding and polishing confronted the engineers with many knotty tasks which were brilliantly solved." (Photo by NOVOSTI from SOVFOTO.)



"The Pioneer Family" — an update courtesy TRW.

Solar Atmosphere Extends Enormous Distance from Sun

Pioneer 10, now a little over halfway between the orbits of Uranus and Neptune, has recorded evidence that the Sun's atmosphere and magnetic envelope "extend an enormous distance — far beyond the point predicted by many scientists," according to James Van Allen, Pioneer investigator.

This discovery means that "if you were living on any other planet, you would find a solar environment surrounding it like that surrounding the Earth. This would include a constant solar wind, buffeting by solar magnetic storms, and, in many cases, radiation belts," said Van Allen (of the University of Iowa) who discovered the radiation belts of Earth that carry his name.

The Pioneer 10 data mean that Voyager 2 will find such "solar" conditions during its encounter with the planet Uranus in 1986. The findings also predict similar conditions for Neptune, which Voyager 2 may reach in 1989.

Results from Pioneer 10 prove the Sun's influence extends out at least 25 astronomical units (AUs) and probably well beyond. The Pioneer scientists found no clear evidence as yet of a close approach to the "heliopause," the border where the Sun's atmosphere encounters interstellar space. Earlier, some astronomers had thought the heliopause might be as close at 5 AUs from the Sun.

Ten Finalists Selected in NASA Student Shuttle Project Contest

Ten finalists have been selected in the first Space Shuttle Student Involvement Project contest, a joint venture of NASA and the National Science Teachers Association.

The project is designed to stimulate the study of science and technology in grades 9 through 12 by engaging students in a competition to develop experiments that could make use of the shuttle's special environment.

The 10 national winners and their teacher-advisors will attend a special conference in August at NASA's Kennedy Space Center. The students will receive instructions and advice on how to prepare their experiments for payload assignment and review the procedures for integrating their experiments into a specific shuttle mission.

Assisted by the sponsor and/or a NASA advisor, the student will analyze the data returned from the experiment and prepare a final report. All scientific data from the student experiments will be in the public domain and made available from the National Space Science Data Center at NASA's Goddard Space Flight Center.

A second Space Shuttle Student Involvement Project contest will open this month with regional conferences to be held in March 1982, and student winners to be selected in May 1982. NASA plans to increase the number of student winners for this competition from 10 to 20 finalists.

The 10 student winners and their experiments are:

Wendy A. Angelo, Poughkeepsie, New York, "Biofeedback."

Aaron K. Gillette, Winter Haven, Florida, "Growth of Porifera in Zero Gravity."

Pritchett A. Harris, Ambler, Pennsylvania, "Simulated Atmosphere on a Weightless Sphere."

Karla R. Hauersperger, Charlotte, North Carolina, "The Effect of Prolonged Space Travel on Levels of Trivalent Chromium in Body."

Michelle A. Issel, Wallingford, Connecticut, "The Formation of Crystals in a Weightless Environment."

Amy M. Kusske, Long Beach, California, "The Effect of Exercise, Diet and Zero Gravity on Lipoprotein Profiles."

Dave D. Madura, Highland, Indiana, "Effects of Space Travel on Cytokinesis and Karyokinesis."

Todd E. Nelson, Rose Creek, Minnesota, "Insect in Flight Motion Study."

D. Scott Thomas, Johnstown, Pennsylvania, "Convection in Zero Gravity."

Daniel J. Weber, New York, New York, "The Effects of Weightlessness on Arthritis."

To broaden participation in the program, NASA is encouraging U.S. industrial firms and other groups to sponsor student winners and assist them in transforming winning proposals into experiments. Industries and other organizations interested in serving as sponsors should write to Glen P. Wilson, Acting Director, Academic Affairs Division, NASA Headquarters, Mail Code LC-16, Washington, DC 20546.

Canadian Group Discovers Organic Molecule in Space

For more than a decade, radio astronomers have probed celestial gas clouds for evidence of complex molecules. Since carbon is quite abundant in these clouds, and can form strong chemical bonds, astronomers were not surprised to find that the most complex cosmic molecules were organic. These have ranged from the simple CO (carbon monoxide) molecule to very heavy molecules reminiscent of those in terrestrial gasoline tanks. Now scientists can add a new member to the list — $HC_{11}N$ (cyano-decapentayne).

The discovery of $HC_{11}N$ followed months of careful searching of the red, cloud-veiled star IRC +10° 216 (also known as CW Leonis) by Morley Bell, Paul Feldman, Sun Kwok, and Henry Matthews — radio astronomers from the Canadian National Research Council's Herzberg Institute of Astrophysics.

Using the Algonquin Radio Observatory in Ontario and the Haystack Observatory in Massachusetts, they found three molecular transitions characteristic of the molecule, and reported their results at a recent meeting of the Canadian Astronomical Society.

At 147 atomic mass units, $HC_{11}N$ is by far the heaviest and most complex molecule yet found in space. The discovery is especially intriguing because studies of the molecule may provide information scientists can't obtain in terrestrial laboratories.

Bell and his colleagues have already determined a fundamental piece of information about the molecule — its rotational constant. This constant indicates how the molecule spins as it absorbs energy and tells scientists about the carbon bonds within it.

Detecting the molecule implies that vast quantities of it must exist around IRC +10° 216. This means that scientists are going to have to figure out how it is synthesized in the very low density envelope around the star — and their theories may include some chemical pathways which do not occur on Earth. *N.L. Cohen.*

ASTRONOMY
REVIEWS

Red Star in Orbit
James E. Oberg
272 pages, hardcover, $12.95
Random House (1981)

What ever became of the Soviet-American space race? You remember — the good old days of Sputnik *vs.* Explorer and Apollo *vs.* Soyuz. Did those "ancient" confrontations end with America's highly successful lunar landings, or are we entering a new era in the competition for space superiority with the Russians? Just how much do Americans really know about the Russian space program, past and present, anyway?

In the aftermath of Apollo, Viking, Voyager, and the Space Shuttle *Columbia*, most Americans probably think that we won the so-called space race and the Russians simply dropped out. Nothing could be farther from the truth.

Red Star in Orbit, a book on the secretive Soviet space program, explodes some fondly-held myths about our arch-rival neighbors in space and uncovers some extremely interesting facts about their practices and problems.

The book's author, James Oberg, a mission controller for NASA, is a respected authority on Russian spaceflight history. His book is a culmination of many years spent deciphering scarce and often scrambled information leaking out of Moscow.

The book is *fascinating*. The information in its thirteen chapters reads like a long-lost history of a forgotten era. Oberg covers and uncovers everything from pre-Sputnik to Salyut 6 and beyond. You simply have to marvel at the obstacles he overcame in writing a book like this.

The Soviets, whether by nature or politics, seem to adore secrecy. Their second fetish is propaganda. Given the monumental task of making sense out of this mess, Oberg has managed quite well at putting pieces together into a clear and concise picture of the Soviet space program. Oberg masterfully transforms clues, apparent dead ends, truths, half-truths, and absolute lies into a smooth text packed with more information and facts than most Soviet space experts probably know themselves.

For example, in two chapters, "The Birth of Sputnik" and "The Nedelin Catastrophe," Oberg demonstrates his adeptness at playing master sleuth. On October 4, 1957, the world's first Earth-orbiting satellite (Sputnik) was launched by the Soviet Union. As Oberg unravels the mystery surrounding the milestone event, we discover that two men, Nikita Khrushchev and the much lesser-known Sergey Korolev, Russia's Robert Goddard, masterminded the feat.

But the two men could not have differed more on Sputnik's real purpose. Korolev was a space enthusiast well before the idea became fashionable. He had studied aeronautics in the 1930s under the great Russian airplane designer A. N. Tupolev. His engineering skills, coupled with his love of flight and a dream of rocket propulsion to the stars, lead him to prominence among his colleagues. But in 1937, all this changed — when the Stalin purges wiped out millions of Russian citizens who were suspected of counter-revolutionary ideas.

Erroneously, but understandably, suspicion fell on Korolev and his rocket engineers and experimenters. The group was arrested and interrogated. Ultimately some were shot, while others, including Korolev, were shipped off to Siberian work camps.

During World War II Korolev was returned to Moscow. The war had increased interest in missiles and rockets because they could be used against the Germans. The Russians also knew that the Germans were developing their own rocket — the V2. So Korolev and some of his former colleagues were called upon to work in this race for a military missle.

After the war Korolev continued working on rockets, a relatively free man. Later, Khrushchev (the driving force behind Russia's feverish "catch-up with the U.S." program) picked up on Korolev's early ideas of sending space vehicles skyward — with satellites aboard. What great propaganda such satellites would be!

Khrushchev cared little for the scientific advantages the satellites could offer. He was driven to make the Soviet Union look like a haven for advanced world technology and scientific sophistication.

After several failures, Korolev successfully built and launched the first satellite into orbit: the race was on.

The second event, shattering in its effects on the Russian program, has been obscured for two decades. The "*Nedelin* catastrophe" occurred three years after Sputnik and was probably the worst accident in the history of space flight. Khrushchev was visiting the U.N. at the time of the accident, and Oberg speculates that his anxiety over accomplishing a well-timed space spectacular contributed directly to the catastrophe.

This is what happened according to Oberg: Korolev was ordered to assemble a rocket to carry an instrument probe to Mars. The package would lift off when a Mars "launch window" opened in late 1961.

News of the impending space shot leaked out, and speculation naturally tied Khrushchev's U.N. visit to the event. But the optimum time for the launch passed with no word of success or failure. Weeks passed with no indication that the attempt had been made.

Eventually, some Soviet spacewatchers hinted of a tragic accident that ended the Mars mission with the deaths of several dozen space scientists. Soviet newspapers reported that a certain Mitrofan Nedelin, a ranking Field Marshal and Russia's top missile general at the time, had mysteriously passed away — precisely when the rumored space shot to Mars would have been launched. Rumor laid the blame for Nedelin's death on a launch-site accident.

The rumor was true. The rocket had failed to ignite, and Nedelin, directly responsible and under terrific political pressure, ordered the problem investigated on the launch pad — *without the standard precaution of unloading the fuel in the rocket.*

As the engineers, technicians, and a few political figures crowded around, the rocket exploded — killing almost everyone nearby, including Nedelin. Speculation has put the death toll as high as 300, but Oberg estimates about 40. Since the disaster affected so many, the event couldn't be totally covered up. A sudden and questionable rash of deaths from accidents and natural causes, however, helped hide it.

Another chapter in the book — "The Moon Race Cover-up" — deserves special mention. Much has been written about how the Soviets never really intended to go to the Moon, but Oberg doubts this.

Oberg explains that Russia's real interest in a manned lunar program ended in December 1968, with the Apollo 8 lunar orbital flight. He states that, early on, the Russians had set their sights to winning the race to the Moon. With Soviet prestige on the line — and an American victory in sight — they were prepared to give up the chase rather than come in second.

The Soviets assumed an American moon landing was not possible until at least mid-1970. They miscalculated, however, and when the agony of an American success became real (along with a knowledge that their own lunar hardware was a failure), the only recourse was to deny they had ever participated. The Moon race, they claimed, was a figment of NASA's imagination. Oberg says otherwise and has the facts to prove it.

The book contains many more chapters on such subjects as Yuri Gagarin's spaceflight, the first woman cosmonaut, failed Russian space missions (some of which were fatal to cosmonaut crews), the guest cosmonaut program, and speculations about the future of the Soviet space program.

The collection of official Soviet photographs of flight crews, rocket launchings, facilities, and personalities is given a fascinating treatment in the book. Using both old and new versions of the same photo, Oberg shows how the Russians have retroactively purged cosmonauts who are no longer alive or who possibly flunked out of training.

The post-Apollo space program in Russia has flourished — in contrast to its American counterpart. With the successes of Salyut-6, one space endurance record after another has

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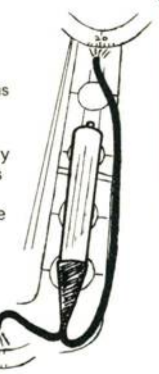

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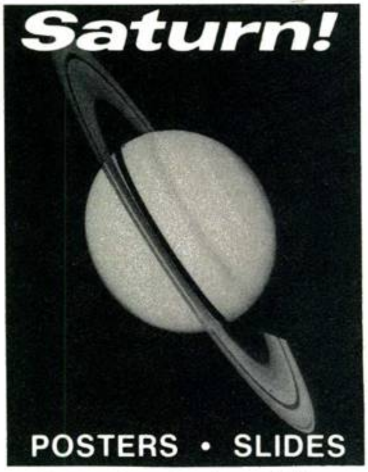

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been smashed — all by Soviet cosmonauts. Their space station and space colonization program deserves recognition for its ambitiousness, its high level of technology, and its impressive record of breakthroughs. Evidently, the Soviets have learned a lot from their mistakes and are now on a road to real achievements in space. Though still present, the propaganda fanfare is muted compared to that of the past. The last thing the Soviets want to do, it seems, is provoke another U.S. space effort.

Red Star in Orbit is highly recommended reading for both the space enthusiast and casual observer. It is an eye-opening account of an incredible era. *Dan Koehler.*

Pictorial Guide to the Planets
Joseph H. Jackson and John H. Baumert
246 pages, hardcover, $22.50
Harper & Row (1981)

Planetary astronomy has reached a point where it makes little sense to discuss each planet by itself, as a world apart from all others. The best books now will be about *processes,* using planets and other bodies as examples. In its third edition, the *Pictorial Guide* follows this format. The book starts with a survey of astronomical basics and then explains clearly the physical aspects of the solar system.

Pioneer: first to Jupiter, Saturn, and beyond
Rochard O. Fimmel, James van Allen, and Eric Burgess
285 pages, paperback, no price avail.
NASA SP-446 (1980)

At long last, this book has reached what will probably be its final form! Issued twice before (in 1974 and 1977 as NASA SP-349 and SP-396 under the title *Pioneer Odyssey*), it tells the story of the Pioneer 10 and 11 probes and the science they radioed back from Jupiter and Saturn. With no more encounters in the offing, the book is the last word on the missions.

The Milky Way
Bart and Priscilla Bok
356 pages, hardcover, $20
Harvard University Press (1981)

It says something for the progress of astronomy — and the popularity of this book — that five editions of *The Milky Way* have appeared in 40 years. In 11 chapters, starting with "Presenting the Milky Way" and ending with "Our Changing Galaxy," the authors explain for the general reader what we know and don't know about our home Galaxy.

Photoelectric Photometry of Variable Stars
D. S. Hall and R. M. Genet
160 pages (approx.), plastic comb bound, $15
IAPPP Communications (1981)
[order from: Fairborn Observatory, 1247 Folk Rd., Fairborn, OH 45324]

For some years now, amateur astronomers who have wanted to make scientific contributions to astronomy have desperately needed an up-to-date book on techniques and equipment for photoelectric photometry. Frank B. Wood's *Photoelectric Photometry for Amateurs* — published in 1963 — was made partially obsolete in only a few years by advances in electronics. Now, authors Hall and Genet have produced a guide to the field that is comprehensive and up-to-date — even though this "pre-publication" edition has some rough edges.

Photometry has become the major scientific work at small observatories, both amateur and professional. This book — with chapters on observatories, telescopes, photometers, electronics, data recorders, and advanced photometric systems — provides enough information for any technically inclined person to construct a photometric system. (I would define a "technically inclined" person as someone who has enough knowledge of electronics to make a circuit board and properly install a diode and sufficient mechanical savvy to place a telescope on a solid mounting.)

Other chapters provide background in observing technique, data reduction, accuracy, and choosing an observing program to keep your equipment busy.

A determined observer with a suitable telescope could build a photometer system in remarkably short order. According to the book, this is all he or she would have to do: Construct the mechanical photometer head in a metal box with a few filters and a Fabry lens. Order the RCA PF 1042 integral H-V power supply and a 1P21 PM tube, and build Art Stokes's one-IC DC amplifier (built around a Signetics NE536 MOS/FET opamp). It might take you a month or two of pleasant evenings in the shop and at the circuit bench. Then you'd be set to go.

This edition of the book is a roughly-edited manuscript and doesn't read as smoothly as it could. The tiny typewriter text makes it tough on the eyes, and some of the diagrams are missing lines. In a few cases, specifications have also been overlooked. However, if you are itchy to get started, these obstacles will seem slight. *Richard Berry.*

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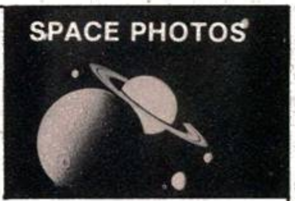

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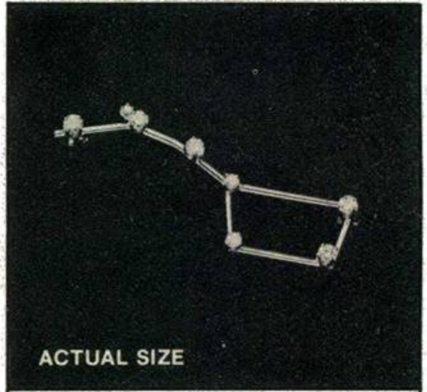

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The Infrared Universe, Part I

by Clarence H. Annett

Modern astronomers are actively exploiting a new window on the universe: the infrared window. This opening enables them to study newly-formed stars, to penetrate into the vast clouds of dust that envelop our Milky Way, and to probe the center of other galaxies. What is infrared? It is simply a portion of the electromagnetic spectrum that has a range of wavelengths between the radio (with wavelengths longer than a few millimeters) and visible light (with wavelengths somewhat less than a thousandth of a millimeter). Infrared means "below red," and the wavelength of the radiation in this part of the spectrum is longer than the red end of the visible spectrum, and hence is not visible to the human eye. Infrared waves are shorter than radio waves, and therefore cannot be detected with radio telescopes.

You have sometimes felt infrared radiation as the heat given off by objects which are hot — but not hot enough to glow. A campfire which has apparently gone out, but continues to give off heat, emits infrared. So does a toaster, so does warm concrete pavement, so, to a lesser extent, does your body. Objects which emit infrared radiation are cooler than those which emit visible light — such as the Sun or the white-hot filament of a light bulb. Long-wavelength infrared photons carry less energy than their visible-light counterparts.

If you plotted the energy given off by cold, cool, warm, hot, and glowing bodies, you would find cool objects radiate principally in the infrared, and as the temperature of the body increases, the major part of the emission shifts from longer to shorter wavelengths. Hot objects glow in the visible portion of the spectrum; cool objects shine in infrared.

This fact is extremely important because it allows us a different view of the universe. The "infrared universe" is a cool one, one of objects too cold to emit visible light, and therefore a universe invisible to our eyes. It differs markedly from the visible universe studied for centuries by astronomers. Since virtually every object in the universe radiates either visible, infrared, or visible *and* infrared radiations, observations in these two spectral regions can provide data on nearly all kinds of celestial objects. In combining the data from the visible and infrared observations, astronomers can learn much more about their nature and history than either set of data alone would reveal.

The University of Wyoming's 95-inch aperture infrared telescope looks much like a conventional Cassegrain telescope used for the visible part of the spectrum. The secondary, however, is smaller than normal for an optical telescope so the infrared contribution of the telescope itself can be minimized. An infrared detector package, attached to the back of the telescope, contains the detector itself, optics, and supporting electronic gear. Photograph by Robert Gehrz.

Infrared is Discovered

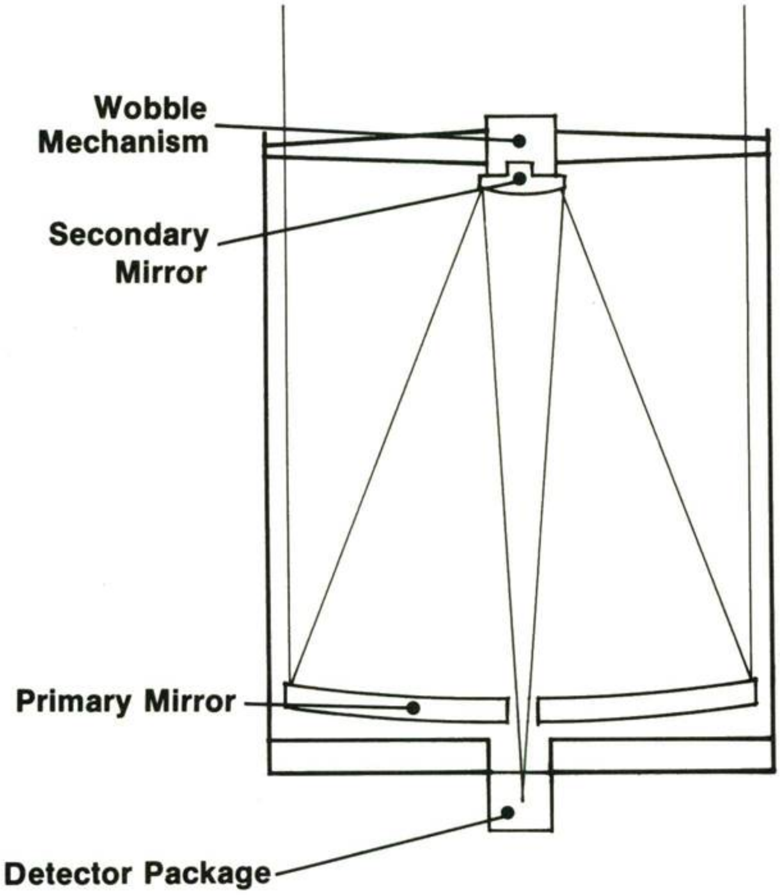
Infrared radiation was discovered early in the 19th century by Sir William Herschel while he was studying the amount of heat produced by various colors of light. Herschel dispersed a beam of sunlight with a prism into a spectrum of colors and, in each of the different colors, he placed a thermometer. Legend has it that he accidentally left one thermometer just beyond the red light band, where he saw no color, and it indicated that heat was present there even though no light could be seen. After further investigation, he announced the discovery of a new form of radiation — the *calorific ray* — so named because it produced more heat than any of the colors of visible light. Since what Herschel had actually observed was the infrared wavelengths of sunlight, his discovery marks the beginning of infrared astronomy. But it was not until 1856 that anyone built a detector sensitive enough for other astronomical observations. Infrared astronomy did not, in fact, blossom until the late 1950s, with the advent of *cryogenic*, or extremely cold, solid-state detectors. Since then, the field has grown explosively.

The infrared spectrum extends from 0.7 micrometer wavelengths — the red end of the visible spectrum — to 1000 micrometers or one millimeter — the shortest radio wavelengths, called microwaves. All radiation lying in this band is called infrared, but it is convenient to make three subdivisions. The shortest wavelength part of the infrared, from 0.7 to 1.1 micrometers, is the photographic infrared. Special photographic emulsions and the sensitive surfaces in certain kinds of image tubes respond to radiation of this wavelength. This makes it possible for astronomers to use some of the same equipment used in visible-light astronomy — reflecting telescopes, photographic plates or films, and special television cameras.

At the other extreme, an ill-defined region near the long wavelength end of the infrared at 1000 micrometers is called the far infrared. Here the wavelengths are so long that the radiation behaves more like radio waves than infrared, and the techniques used to detect and measure it resemble those used in radio astronomy. This region is loosely called the *submillimeter region* because the wavelengths are close to, but less than, a millimeter.

Between these two regions — where the major portion of infrared radiation occurs — lies the mid-infrared. Neither photographic emulsions nor radio methods can detect it; instead, astronomers and physicists must employ special methods applicable only to infrared radiation. The slow development of infrared detecting techniques held up the emergence of infrared astronomy for nearly a century.

An infrared telescope works much the same as a Cassegrain telescope for visible light — infrared radiation from a star strikes the primary, is reflected to the secondary, then back to a detector. Often the secondary mirror "wobbles" the infrared images back and forth so that the changing signal can be more readily separated from the stray radiation from the telescope and the sky.



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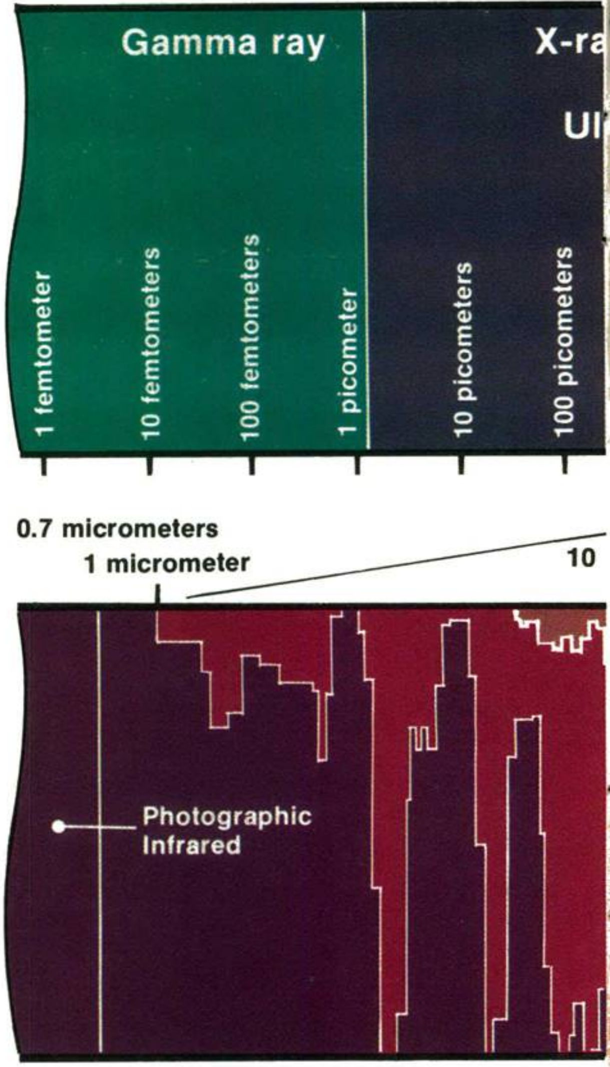


Detecting Infrared

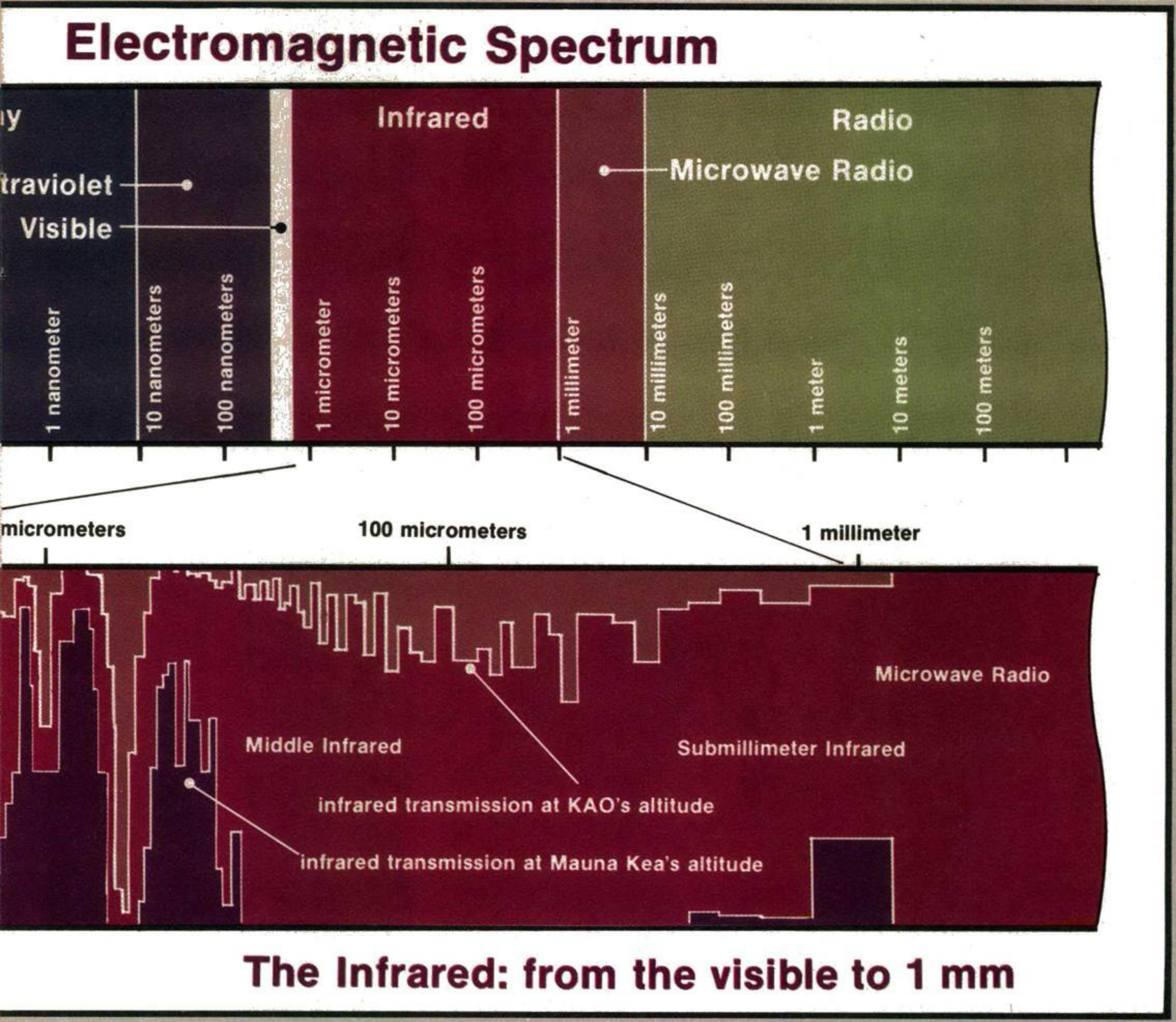
Infrared detectors are often called *bolometers*, a term for a detector which responds to all wavelengths equally. But many infrared detectors depart significantly from this ideal, and are very wavelength-dependent. Despite the confusion, use of this term persists.

The simplest bolometers make use of Herschel's discovery — that infrared radiation heats any object it shines on. Early infrared astronomy was done with the thermocouple detector, in which infrared radiation striking the junction of two dissimilar metals produced a small voltage proportional to the amount of heat produced. Unfortunately, thermocouple junction devices are not very sensitive and cannot be used for faint astronomical objects. Other bolometers measure the expansion of a small sample of trapped gas, heated by infrared radiation, but again, are not very sensitive.

Newer, more sensitive detectors include lead sulfide (PbS) and germanium (Ge) crystals *doped*, or contaminated, with tiny amounts of impurities. The flux of infrared photons causes electrons to be detached from the atoms in the crystal, causing a current flow. Cooling the detector enhances the effect, and also reduces electronic noise. For this reason, the detector is surrounded by a container of a liquified gas with temperature very near absolute zero. Lead sulfide detectors work best at 77° Kelvin (-196° F), and doped germanium detectors require colder temperatures still — 4.2° Kelvin, the temperature of liquid helium. Keeping the detectors this cold is one of the big problems in infrared astronomy.

Lead sulfide detectors work best in the 1 to 4 micrometer wavelength region. With longer wavelengths, a doped germanium detector must be used. It consists of a tiny crystal of pure germanium into which a few atoms of another element such as copper, mercury, or gallium have been diffused. In the process of doping, the proper choice and amount of dopant can increase the sensitivity of the detector and change the wavelength of maximum sensitivity.

A few exotic crystals like indium antimonide (InSb) have been successfully used as detectors at certain infrared wavelengths; they depend on the same physical principles for their operation as the PbS and Ge crystals. At this stage of technology, making these detectors is still much more of an art than a science, and the finished product is quite expensive.



Electromagnetic Spectrum

The Infrared: from the visible to 1 mm

Infrared Telescopes

How do infrared telescopes differ from telescopes used for visible light? At the short wavelength end of the infrared band, photographic infrared, there is no difference. Only a few filters and a box of special infrared photographic plates distinguish the infrared astronomer from his optical colleagues.

At longer wavelengths, the differences start to mount up. First, the eyepiece or plateholder must be replaced with an infrared detector and its supporting electronics. Refracting telescopes cannot be used at all because their glass lenses transmit virtually no infrared radiation. Reflecting telescopes work well because highly-polished aluminized mirrors absorb very little of the infrared radiation which strikes them.

Reflectors used primarily for infrared can be lighter, shorter, and less optically-precise than optical telescopes. The long wavelength of the radiation still requires a quarter-wave mirror, but the wavelengths are now many times longer. For the same aperture, an infrared telescope is considerably less expensive than an optical telescope.

But the biggest difference between visible-light and infrared telescopes is that an infrared telescope must *nod*, or switch, back and forth from the object under examination to a nearby patch of sky. Nodding is necessary because the infrared sky is not dark — so infrared astronomy is like optical astronomy done in the daytime with a telescope that glows. Infrared astronomers frequently don't care whether it's day or night when they observe. Why? The Earth's warm atmosphere always radiates a substantial quantity of infrared radiation at all wavelengths, and the telescope itself is a source of infrared radiation.

Nodding or Wobbling

Nodding solves the problem by alternately looking at the astronomical object of interest and the background sky. The unwanted infrared "sky plus telescope" background can be electronically subtracted from the "object plus sky plus telescope" signal to leave just the "object" signal. Because the infrared brightness of the Earth's atmosphere changes continuously and somewhat randomly with the temperature, background subtraction is an absolute necessity if any sense is to be made of infrared astronomical data. Background subtraction also allows observations of many strong infrared sources in the daytime. The most common way to make the telescope nod is to use a small

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The 24-inch aperture Infrared Astronomical Satellite telescope (IRAS) will be launched in 1982. This telescope, built to survey the entire sky in the infrared, will be cooled to 4°K by a jacket of liquid helium. The IRAS could detect as many as a million infrared objects (many for the first time), including extremely distant quasars, objects in the center of our Galaxy, low-luminosity infrared stars and new solar system members undetected in the visible spectrum. NASA/Ames Photograph.

motor to wobble the secondary mirror back and forth about 20 times each second, and place the infrared detector at the Cassegrain focus of the telescope. Not only is this method relatively easy, but it also returns the object of interest to the center of the field of view with sufficient precision.

Besides generating its own infrared *noise*, our atmosphere is troublesome to infrared astronomers in another way: it is a very good absorber of infrared radiation. Of the entire infrared spectrum, only three narrow wavelength bands pass through the atmosphere and make it all the way to sea level without significant diminution. The bands lie between 2 and 25 micrometers, 30 and 40 micrometers, and 350 and 450 micrometers. Infrared radiation of almost all other wavelengths is either completely absorbed or attenuated so much by the atmosphere that astronomy at ground level is impossible.

The strong absorption which denies ground-based astronomers access to so much of the infrared spectrum is principally due to water and carbon dioxide molecules in the atmosphere. Thus the problem of absorption can be overcome, at least partially, by getting above as much of the atmosphere as possible, and by locating in a place with a dry climate. While most of the world's major reflecting telescopes have at some time been used for infrared observations, the best observations have come from telescopes which are at high altitudes and in dry climates.

High and Dry

Astronomers locate infrared telescopes at sites especially selected for these characteristics. In Hawaii, several infrared telescopes are being constructed or have recently been put into operation at a site atop Mauna Kea volcano — at an altitude of about 14,000 feet. At this height, clouds seldom interfere with observing, and there is much less water vapor than at lower altitudes — about 50% as much in fact — although the diminished supply of oxygen makes it harder for astronomers to work.

Between 40 and 330 micrometers in wavelength, no ground-based site is high enough to allow observation of anything less bright than the Sun or the Full Moon. From 450 to 1000 micrometers, the atmosphere is nearly impervious to infrared radiation. Therefore, observations in these parts of the far infrared depend on the telescope being carried to altitudes in the stratosphere, 30 to 40 kilometers high, where it is above 99% or more of the atmosphere. Astronomers first accomplished this by sending small telescopes aloft by balloon. Even today, unmanned balloon-borne telescopes are still the mainstay of infrared astronomy at all wavelengths. Rather large telescopes, with primary mirrors up to one meter in diameter and weighing as much as two tons, can be sent up to the required altitude, kept up for several days (depending on the weather), and then brought down to a soft landing without damaging the telescope or its instrumentation.

These telescopes look like small versions of large ground-based telescopes — but their mounts are alt-azimuth instead of equatorial. The instrument package carries gyroscopes for pointing the telescope accurately and keeping it on target, all the necessary detector electronics and cooling apparatus, and radio equipment to transmit the data back to the ground and receive commands for pointing and repositioning the telescope.

Infrared telescopes have also been mounted on aircraft. The astronomer and one or more technicians can ride with the telescope, carry out the observations, and make repairs or change the observing program. Aircraft, however, cannot fly as high as balloons (jet engines become starved for oxygen above 12 to 15 kilometers), so the observations cannot last as long as with balloons, and the cost is much greater. These disadvantages notwithstanding, airborne infrared telescopes are making a real contribution to infrared astronomy. NASA routinely operates a small telescope aboard a Lear Jet and, since 1975, has carried out observations in the Gerald P. Kuiper Airborne Observatory (KAO).

KAO is a specially-designed C-141 *Starlifter* aircraft which carries a 36-inch Cassegrain reflecting telescope outfitted for infrared observation. It houses spectrometers, onboard computers, a small staff of technicians, and all the facilities necessary for a well-equipped observatory. KAO is best known for providing the data which led to the discovery of the rings around Uranus when the planet occulted a star in 1977. (See "KAO: Mission Incredible," June 1980.)

And into Space. . .

Between 1970 and 1975, the United States Air Force used rockets to put several infrared telescopes above the atmosphere for a brief period. The rockets spun so the telescope could scan a large area of the sky in the short duration of the flight. From this data, a catalog — *Infrared Astronomical Objects*, containing 2066 bright sources observed at 4, 11 and 20 micrometers — was published in 1975. The sky has not been so completely mapped at any other infrared wavelengths.

The ultimate solution to the problem of getting above the Earth's moist atmosphere and staying there long enough to observe more than a handful of faint infrared sources is to place a telescope in orbit around the Earth. Small infrared telescopes have been orbited on several satellites since 1969 and have provided important long-term observations of many infrared objects, including planets and variable stars. However, these telescopes were too small to be useful in observing extended sources such as the galactic center, and their angular resolution was too limited to provide any usable data on many interesting objects.

At the present time, work is moving ahead on the Infrared Astronomy Satellite (IRAS), a joint United States/United Kingdom/Netherlands project. The IRAS will carry a 60 centimeter infrared telescope and associated instrumentation. Its primary mission will be to survey the entire sky at mid and far-infrared wavelengths so a much-needed catalog of sources can be compiled. Such a survey has not been possible with balloons or aircraft; data are extremely sparse for the southern hemisphere, where there are few facilities for launching and recovering large balloons and rockets.

Meanwhile, there are plans to place a very large telescope in orbit. The Space Telescope, which is tentatively scheduled for operation about 1985, will be the largest telescope ever to orbit. It will have a 2.4 meter diameter mirror and will carry detectors and spectrometers for observation in the ultraviolet, visible, and infrared portions of the spectrum. The Space Telescope will be placed in orbit by the Space Shuttle, and after several years of continuous use, the Shuttle will recover it and return it to Earth for repair and refurbishing and then return it to orbit. High above the atmosphere, the Space Telescope will provide 24 useful hours of observation time each day. It will be a giant leap forward for infrared astronomy in the same way the 200-inch Hale Telescope was for visible-light astronomy. Designs for other large infrared observing satellites which could be placed in orbit by the Space Shuttle are currently under serious study.

Clarence Annett is an instructor at the University of Kansas Physics Department, and has taught in the Kansas State University planetarium. His last article for ASTRONOMY was "The Radio Universe," a two-part series in the March and April 1980 issues.

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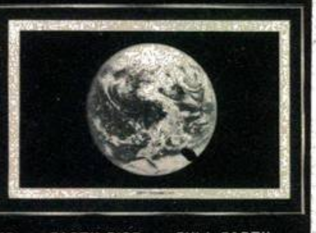

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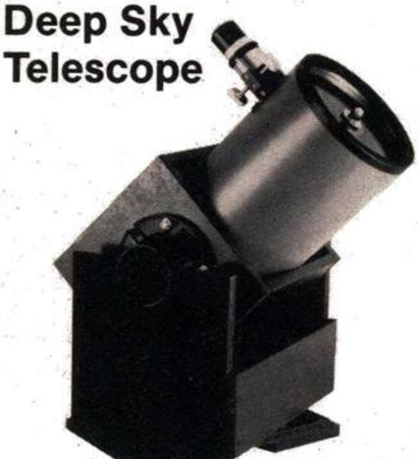

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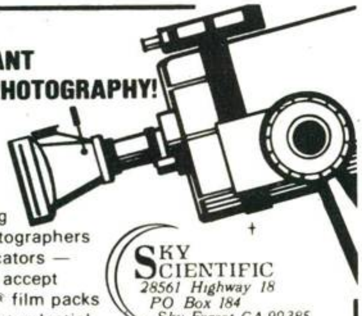

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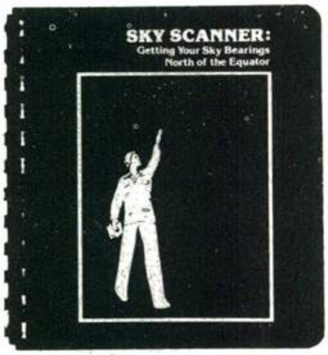
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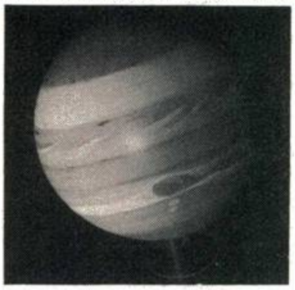

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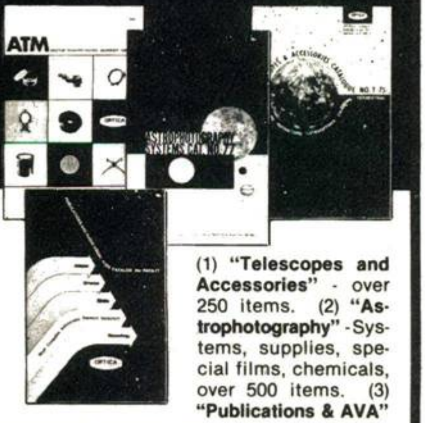

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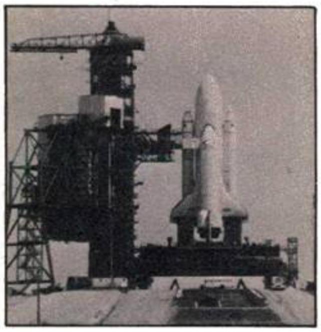

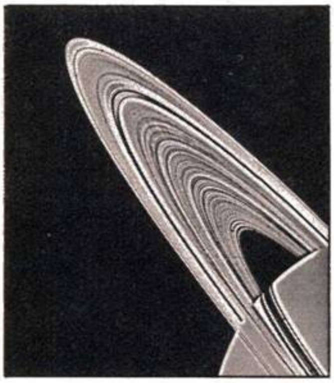

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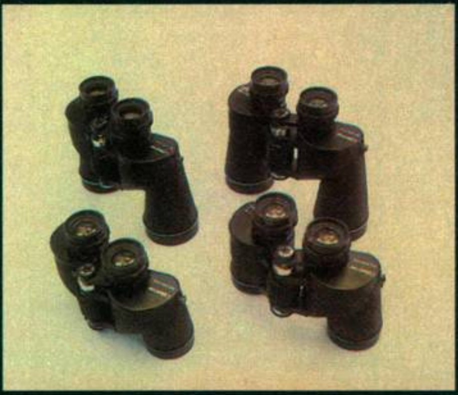
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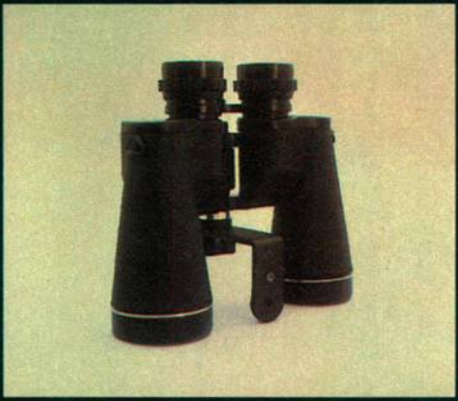
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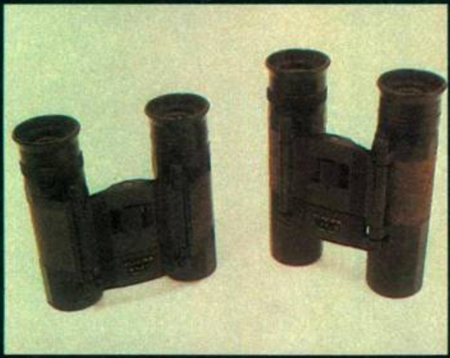
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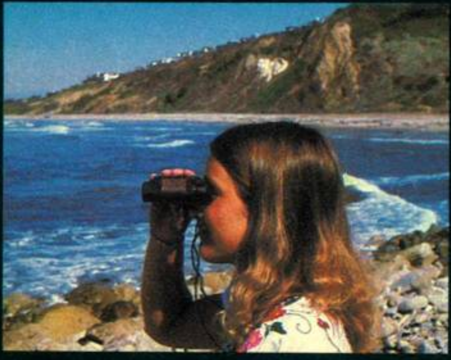
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In short, Celestron binoculars are the first and only moderately priced glasses to meet our standards for astronomical viewing. What does this extra quality mean for ordinary viewing? It means, simply, unexcelled performance whether used for bird watching, nature viewing, hunting, boating, or general viewing.

Celestron binoculars are a very relaxing way to view astronomical or terrestrial subjects. When both eyes are used, viewing is relaxed and comfortable, the subject will seem brighter and have a three-dimensional quality associated with it. The fields of view are wider with binoculars than with higher power telescopes, so binoculars are excellent for sweeping scenic landscapes or the expanse of the Milky Way.

A binocular's name describes its magnification and lens diameter; for example, an 11x80 binocular is 11 power and has objectives (light gathering lenses) 80mm in diameter. Different binoculars are better for some applications, some of which we will point out in our descriptions below.

Giant Series

Celestron is proud to offer three giant binoculars, of 80mm aperture, that far outperform smaller binoculars for astronomical application. These giant binoculars also offer superior performance in sporting events, surveillance, hunting and view home application where extreme portability is second to optimum performance. Celestron giant binoculars come standard with: a photo-tripod adapter to adapt the binoculars to a standard photographic tripod (tripod not included), fully coated optics for maximum image sharpness and contrast, color corrected achromatic objectives, a carrying case and straps, lens caps, center focus for rapid focus adjustment, sleek body style, and superior optical and mechanical performance. With Celestron binoculars you'll be assured of optimum instrument performance with the rugged reliability, uniformly sharp performance and value that has made the name Celestron legendary in optics.

All giant binoculars can use our #6 LPR filter for enhanced viewing of emission nebulae (huge clouds of glowing dust and gas between the stars).

- **11x80 binoculars** — These are the lowest power of our giant binoculars; thus, they offer the widest field of view and brightest images (4.5° and 7.3mm exit pupil). These would be best suited for deep sky observing under very dark skies, and especially useful for viewing large, faint objects. Good for terrestrial applications especially during twilight conditions. Tripod recommended.

- **20x80 binoculars** — These are, perhaps, the optimum high-power, deep sky or terrestrial binocular. The higher magnifications often allow fainter stars to be observed, smaller deep sky objects to be noticed and detail to be made out in brighter deep sky objects. The image is still bright (4.0mm exit pupil) and the field of view is still wide (3.5°) for very pleasing deep sky observing. In addition, these give superior daytime performance because of the smaller exit pupil (small enough so that your eye can accept it entirely). Tripod required.

- **30x80 binoculars** — The 30x80 binoculars offer high power binocular viewing for detailed binocular study of bright deep sky objects and the moon. The first quarter moon is a spectacular target. These binoculars will show hundreds of craters. A view homeowner or bird watcher who observes from a fixed location will find these binoculars a joy to own. Since the eye relief is small, individuals who must use eyeglasses while using binoculars should order our 20x80 or 11x80 binoculars. A sturdy tripod is required. Because of the higher power of these binoculars, you can see a larger image but the brightness will be lower (2.7mm exit pupil). The field of view is 2°

Giant Series of binoculars

Giant Series mounted on a tripod (optional)

close-up on aquarius

through the eyepiece

Mercury

During September, Mercury moves out to the east of the Sun, reaching greatest elongation on the 23rd, but its southerly declination (-12° 30′) means that it will set less than an hour after the Sun does.

Even though you'll be looking in twilight, the planet won't be too difficult to find, because it lies just below Saturn and Jupiter early in the month and very close to Spica later on. Mercury's conjunctions with Saturn and Jupiter (on the 10th and 13th, respectively) will be too distant — 4° and 3° — to fit all the planets into the eyepiece of anything more powerful than binoculars or a very low power RFT.

But the close conjunction (23′ 30″ separation, Mercury to the south) with Spica on the evening of the 20th will be superb in low or moderate-power eyepieces. Spica is a bluish-white star of magnitude +1.0; Mercury's 6.5″ disk will be slightly brighter (magnitude +0.2) and about 65% illuminated.

Venus

Brilliant Venus will overtake Spica on the evening of September 6, when it will pass 2° north of the star. At magnitude -3.5, the planet far outshines first magnitude Spica. Its 75% lit, featureless white disk will be about 18″ of arc across.

Earth

The Sun's center crosses the celestial equator "southbound" at 3:05 UT on the 23rd, marking the commencement of northern hemisphere autumn; Earth's distance from it is 1.00339 AUs and decreasing.

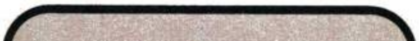
Although Jupiter is beginning to lose its prominent position in the evening sky, photos like this one will remind us of its splendor. Donald Parker made this 1-second exposure at f/96 on 200 ASA film through a 12½-inch Newtonian. Seeing was rated at 10. This is the "Best Astro-Photo" award winner for September.

Mars

The big event for Mars watchers this month will be the planet's passage through the Beehive Cluster, M-44. A loose, open aggregation, the Beehive contains some 200 to 300 stars ranging in magnitude from 4.5 down to about 17 — in a diameter of a degree and a half.

On the morning of the 13th, Mars will be nearest the cluster's center, with the planet passing some 13′ of arc south of it. Since M-44's angular diameter is so large, you'll need your lowest power (longest focal-length) eyepieces. Indeed, binoculars may provide the best general view.

Of course, the event isn't limited to just a single morning. For several days before and after, you can watch Mars approach the cluster from the west, transit it, and depart eastward. Photographs taken at daily intervals during the week previous to the passage and continuing a week after will make a very striking series.



On the morning of the 24th, the Moon, a very thin crescent, will be to the east and below Mars. Observers on the eastern hemisphere of Earth will see an occultation, but the pair rises too late for us to witness it.

Asteroids

1 Ceres is in conjunction with the Sun on September 15.

2 Pallas (magnitude 8.8) moves from eastern Hydra into western Sextans this month. On the 26th, it will be about 16° south of Regulus (Alpha [α] Leonis). Its positions:

10th: 9h 35m 29s, -2° 17.3′
20th: 9h 55m 55s, -3° 09.8′

Pallas rises in morning twilight: around 5:50 a.m. local daylight time at mid-month.

3 Juno (11.5) lies in eastern Virgo/western Libra during September. Its positions:

10th: 14h 30m 40s, -4° 37.5′
20th: 14h 41m 31s, -5° 38.6′

Juno will set around 8:45 p.m. local daylight time on the 15th.

4 Vesta (8.0) is in eastern Virgo. Its positions:

10th: 13h 13m 29s, -2° 23.8′
20th: 13h 32m 03s, -4° 27.5′

At mid-month, Vesta sets about 8:20 p.m. local daylight time.

Jupiter and Saturn

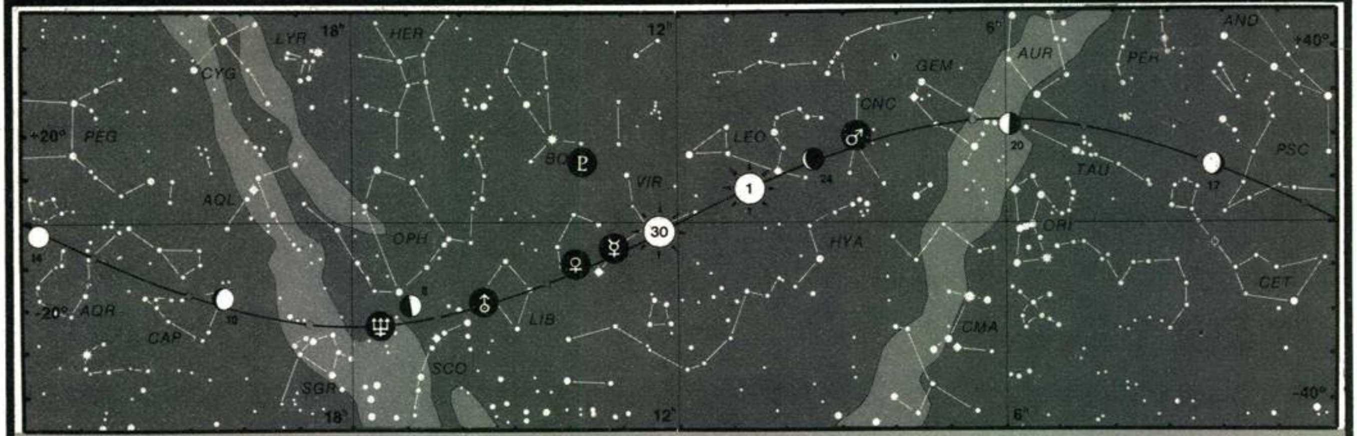
The Great Conjunction is over and both planets are low in the west at sunset. Conjunction with the Sun comes next month on the 6th for Saturn, the 14th for Jupiter.

You'll have to make your telescopic farewells through a thickening blanket of atmosphere that ruins definition, but these planets will be back in the morning sky for at least part of November and all of December at the start of their next apparition.

Uranus

Uranus has finished its retrograde

planetary data september 1981


LYR
18h
HER
12h
6h
AND
+40°
CYG
GEM
AUR
PER
CNC
+20°
PEG
LEO
♂
20
PSC
BO
♇
24
TAU
VIR
1
17
AQL
30
14
OPH
☿
♀
HYA
ORI
CET
-20°
AQR
10
8
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LIB
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♆
CMA
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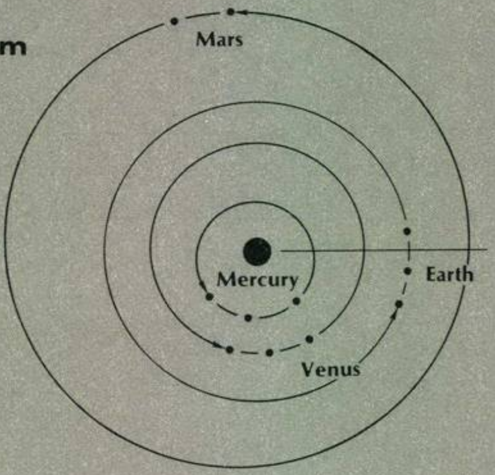
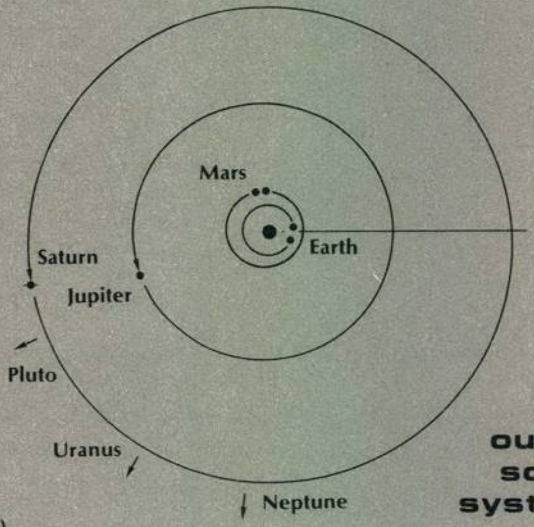
-40°
18h
12h
6h

inner solar system


Mars
Mercury
Earth
Venus

outer solar system


Mars
Earth
Saturn
Jupiter
Pluto
Uranus
Neptune

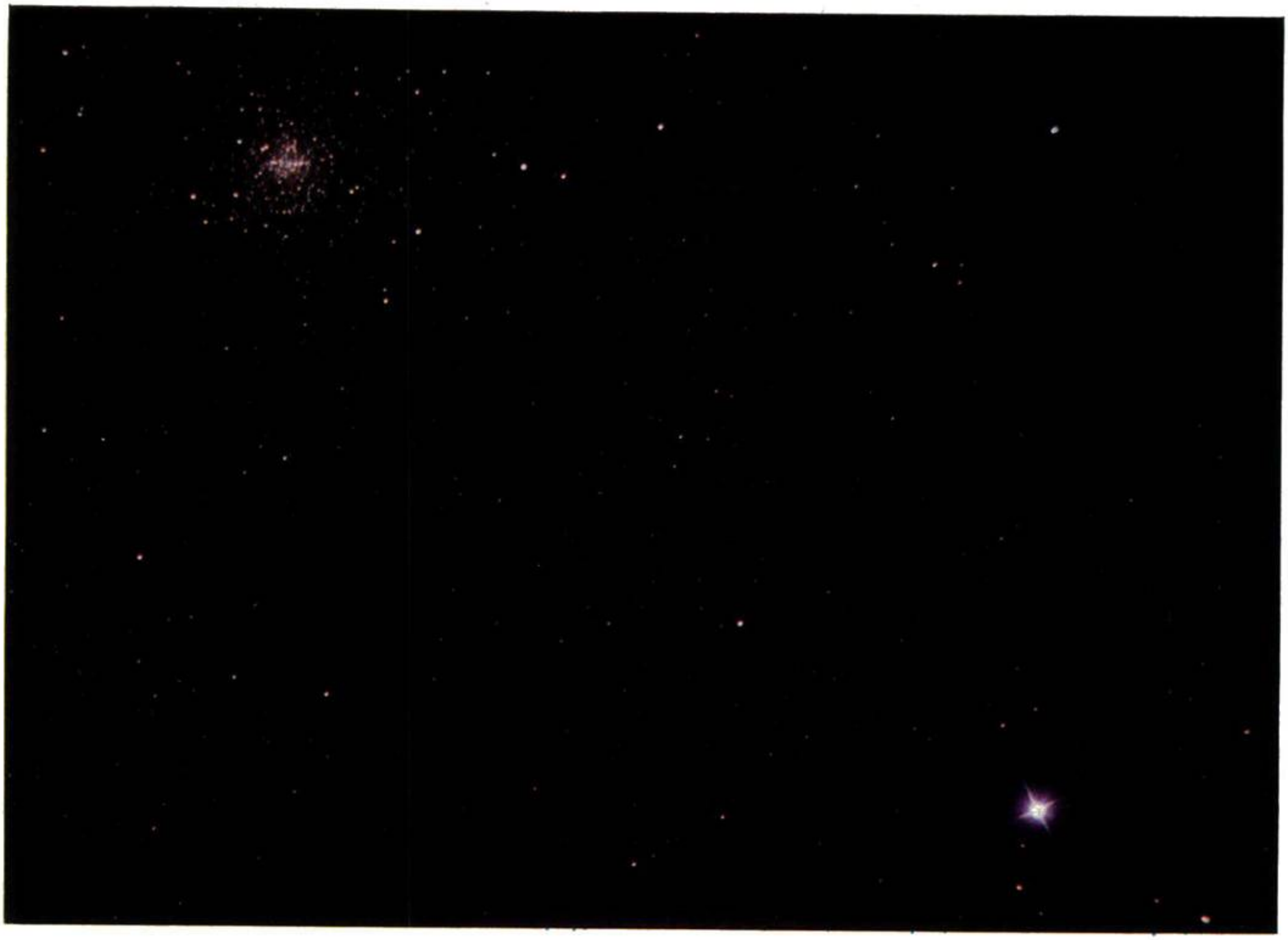
		Date	Mag.	Angular Size	% Illum.	Distance (AU) from:		Longitude:		R.A. (1981.8)	Dec
						Earth	Sun	Heliocentric	Ecliptic		
Sun		1	-26.7	31.7′	—	1.01	—	—	158°28.6′	10h 40.4m	+8°23.7′
		15	-26.7	31.9′	—	1.01	—	—	172°04.2′	11h 30.8m	+3°09.0′
		30	-26.7	32.0′	—	1.00	—	—	186°45.1′	12h 24.8m	-2°40.6′
Mercury	☿	1	-0.2	5.3″	85%	1.27	0.45	222°51.8′	176°29.3′	11h 49.3m	+1°24.7′
		15	+0.2	6.0″	71%	1.11	0.47	262°12.4′	196°23.5′	12h 59.8m	-8°10.3′
		30	+0.4	7.6″	46%	0.87	0.43	306°28.0′	211°05.9′	13h 53.6m	-15°13.9′
Venus	♀	10	-3.5	14.9″	74%	1.13	0.73	267°59.7′	206°05.9′	13h 37.8m	-10°38.7′
		30	-3.5	17.1″	67%	0.98	0.73	299°37.9′	229°18.1′	15h 07.2m	-19°19.8′
Mars	♂	15	+1.8	4.3″	95%	2.16	1.60	102°17.6′	127°42.4′	8h 43.4m	+19°17.0′
Jupiter	♃	15	-1.2	30.9″	100%	6.37	5.45	198°33.4′	194°04.8′	12h 55.1m	-4°41.9′
Saturn	♄	15	+1.1	15.8″	100%	10.56	9.61	192°08.8′	189°49.9′	12h 41.2m	-2°01.3′
Uranus	♅	15	+5.9	3.6″	100%	19.24	18.83	239°33.3′	236°29.7′	15h 38.1m	-19°15.3′
Neptune	♆	15	+7.8	2.4″	100%	30.26	30.27	264°02.1′	261°47.7′	17h 26.0m	-21°54.0′
Pluto	♇	15	+14.0	—	100%	30.84	30.02	204°03.3′	202°38.0′	13h 49.7m	+6°30.9′

moon data

First Quarter .... September 6 at 13:26
Full Moon .... September 14 at 3:09
Last Quarter .... September 20 at 19:47
New Moon .... September 28 at 4:07
First Quarter .... October 6 at 7:45
Full Moon .... October 13 at 12:49
Apogee: September 5 at 7h .. 404,448 km
Perigee: September 17 at 4h .. 365,622 km

universal time

Astronomers the world over use an unambiguous system of time reckoning — Universal Time (UT) — based on a 24 hour clock. Times given in Through the Eyepiece are UT unless noted otherwise. To convert UT into your local daylight time, subtract the following number of hours for each time zone: EDT, 4; CDT, 5; MDT, 6; PDT, 7; Alaska, 9. For example, if an event is to happen at 03:00 hours UT on June 7, then EDT for the event is 11 p.m., June 6. Likewise, 03:00 UT on September 2 becomes, in PDT, 8 p.m., September 1.



Antares and its nearby neighbor M-4 set shortly after twilight in the fall skies. Mike Morgan made this shot from a dark Arizona sky location using a 10-inch f/4 Newtonian and 400 ASA film in a cold camera. The exposure lasted 6 minutes and recorded stars down to 12th magnitude.

loop and has resumed eastward (direct) motion again. On September 12 (at about 19:37 UT), it will pass 7″ of arc north of the star Iota (ι) Librae. Iota is at magnitude +5.5, Uranus +5.9; Uranus' disk measures 3.6″ of arc across.

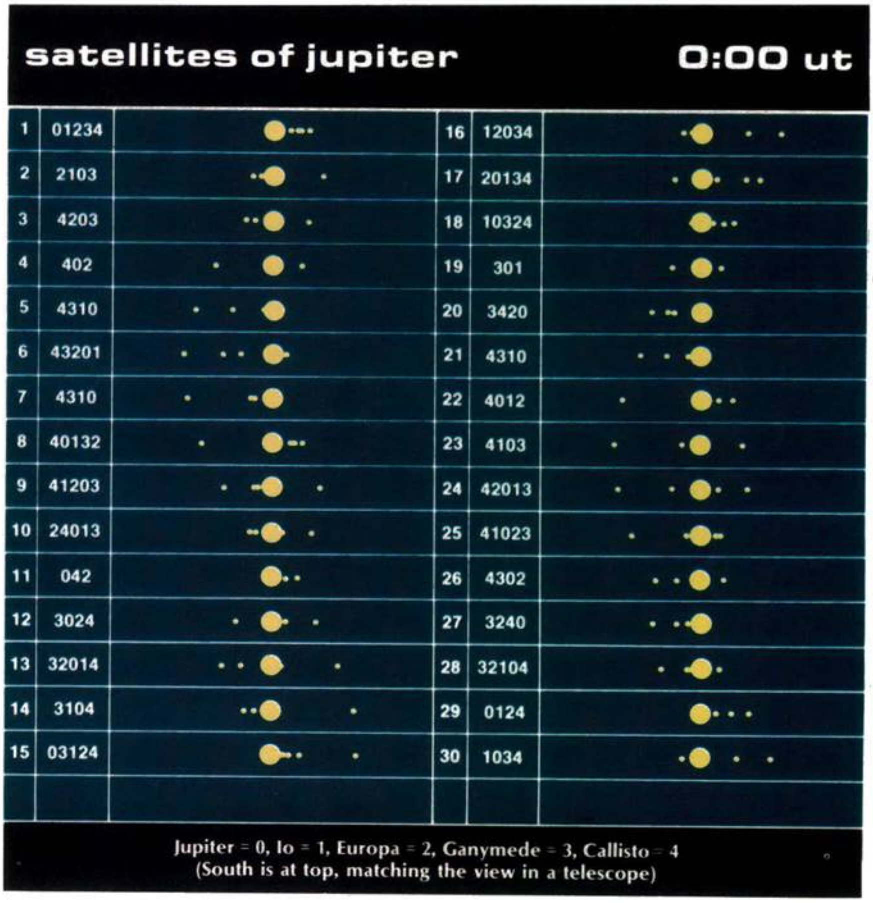
At the time of conjunction, it is still daylight over North America, so observers here will have to settle for seeing the star-and-planet duo after sunset that evening.

Neptune

Stationary in right ascension on the 3rd, Neptune's motion thereafter will be to the east: about 1.6 seconds of right ascension per day. Neptune has a brightness of +7.8 magnitude, and its disk is 2.4″ of arc across.

close-up on aquarius

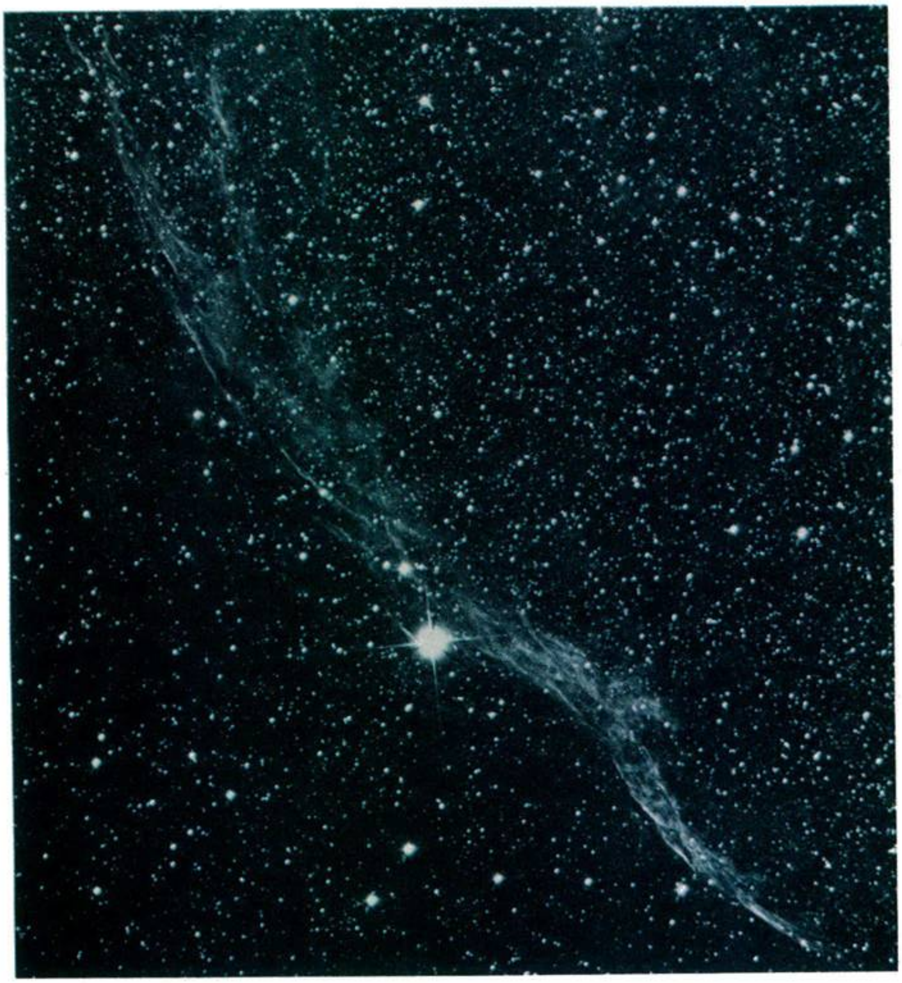
Aquarius the water-carrier is one of the many "wet" constellations of the



satellites of jupiter **0:00 ut**

1	01234	16	12034
2	2103	17	20134
3	4203	18	10324
4	402	19	301
5	4310	20	3420
6	43201	21	4310
7	4310	22	4012
8	40132	23	4103
9	41203	24	42013
10	24013	25	41023
11	042	26	4302
12	3024	27	3240
13	32014	28	32104
14	3104	29	0124
15	03124	30	1034

Jupiter = 0, Io = 1, Europa = 2, Ganymede = 3, Callisto = 4
(South is at top, matching the view in a telescope)



A wealth of galactic detail is recorded in this 50-minute exposure of M-31's nucleus, (right). John P. Gleason used a 14-inch Schmidt-Cassegrain at f/11 for this shot on ASA 400 film. The Veil Nebula, NGC-6960, (above) is rarely recorded in black and white. Alfred Lilge made this 75-minute exposure with his 12½-inch f/8 Newtonian on 103aF emulsion.

autumn sky. It is also ancient — Allen, in his classic book, *Star Names,* mentions that even in Babylonian times, constellation watchers described the man-and-water-jug figure we still associate with it.

Tracing out the figure calls for dark skies because, like many of its neighbors, Aquarius is not very prominent. (This alone would tell you it dates back to pre-industrial times!) The brightest star in it is **Beta** (β), (magnitude 2.89) followed closely by **Alpha** (α) at 2.93. The rest of the figure-stars are of third and fourth magnitudes.

The names of Alpha and Beta, like so many others, have come to us from Arabic. Alpha is Sadalmelik, "the lucky one of the king," and Beta is Sadalsuud, "the luckiest of the lucky."

Just to the east of Alpha is an asterism of four 4th magnitude stars forming a flattened letter "Y". The asterism has been named the **Water Jar** — as befits its place in the older renderings of the figure. Modern depictions make the constellation look like a pair of squashed wire-rim spectacles: the two "lenses" are the eastern and western water jars and the "Y" asterism in the middle is a yoke lying across Aquarius' shoulders.

Though it's fun to trace out the shape of the constellation and speculate on what each star represents, the glories of Aquarius really come alive when you turn your telescope on it.

Let's start with the center star in the "Y", the double star **Zeta** (ζ). The two stars making up the system have individual magnitudes of 4.42 and 4.59 — when combined, 3.99.

Both components have similar spectra, being "early" (hotter) F class. T.W. Webb listed their colors as greenish white — most people see them as white or nearly so. Taking the A component as a reference point, B lies just under 2 seconds of arc to the southwest (position angle 230°). The orbital motion is clockwise, but the period is uncertain; 850 years seems to be the best estimate. The separation is now increasing very slowly, but it won't pass the 2″ mark before the end of the century. The system lies some 75 light-years away.

Easy to find, Zeta is also a good challenge for a small telescope — a test of seeing as well as instrumental quality. Webb described it as "a very fine object, easy with small aperture," but his observation dates from the middle of the last century, when the separation was about twice what it is now. On a night of steady seeing, moderate power (100x to 175x) with a 3-inch should split the pair well. With a smaller scope — a 60 mm refractor, say — you'll find the quality of the seeing and the instrument itself become much more important. If you want to resolve the two, you may be limited to only the best nights.

Let's now shift our attention from Zeta, on down the line of stars to the eastern water jar. There, near the

naked-eye pair of Omega^1 (ω^1) and Omega^2 (ω^2), we'll find a classic variable star of the long-period, "Mira" type: **R Aquarii**.

Long-period variables (LPVs) usually have a brightness range that spans some five to seven magnitudes, though this can vary considerably — even in the same star. The range of R Aqr is from about six at brightest to about twelve at dimmest; the period averages 387 days, with some period-to-period variation. Having been brightest in spring this year, it will probably be at minimum light in November.

Since LPVs are all cool M-type giant stars, they are orange in color. The spectrum of R Aqr is peculiar; along with its normal M-type spectrum, there is evidence of a hot, blue, O-type dwarf companion star, also variable. Moreover, long-exposure photographs have revealed a cloud of gas around the star — perhaps a planetary nebula in the making.

Naturally, your telescope isn't going to show the nebula or the spectrum, but when you gaze at R Aqr and track its brightness changes, keep in mind that you are looking at a very unusual star system.

About 4° south of R Aqr and a little east lies the double star **107 Aquarii**. Its two components, an A5 star of 6th magnitude and an F2 star of 7th magnitude, have a separation of about 6.5 seconds of arc. The B component lies to the southeast of the A star. Their spectral classes indicate their intrinsic colors: white and not-so-white. Webb quoted a good number of previous observers' color estimates — variations on white and yellowish, mostly — and added his own: yellow and lilac. What do they look like to you?

In the center of Aquarius' eastern water jar, some 4.5° south of the triplet Psi^1, Psi^2, and Psi^3 (ψ), lies a widely-spaced double star system — **94 Aquarii**. Separated by 13" of arc and lying almost north/south, the yellow-white and white components (magnitudes 5.3 and 7.5) will pose no resolution problems for even a small telescope at low power.

Our next object is the giant planetary nebula, the **Helix**. Situated in the southern part of the constellation, the Helix (NGC-7293) lies some 21°

Though not a prime target of astrophotographers, M-7 is a jewel-box of stellar images — breath-taking in a large scope. Here, it was photographed with a 12½-inch Newtonian at f/8. A 2-hour exposure recorded this exceptional detail on 103aF. Alfred Lilge, a Californian, submitted this shot.

south of Zeta, the double star at the center of the "Y".

At half the apparent diameter of the Moon — 12′ by 15′ of arc — the Helix is the largest planetary nebula. It has an integrated magnitude of 6.5, but its very low surface brightness makes it surprisingly hard to find in a telescope. You'll do best if you go well away from city lights and use binoculars or a low-power RFT.

Your difficulties in spotting this nebula may tempt you to haul out a 6 or 8-incher. But if you do, you'll probably have difficulty getting a low enough power, given the focal lengths available with commercial eyepieces. Besides, you won't need the "light-bucket" approach — just a *black* sky.

The Helix gets its name from the appearance it has in photographs. It looks like a giant cousin to the Ring Nebula (M-57) in Lyra, but with more twists and knots in the "smoke ring." In reality, it is a giant bubble of tenuous gas surrounding a hot 13th magnitude central star. The bubble has a diameter of about a light-year and a half.

If you know you've found the Helix, but just can't quite glimpse it, try the old observers' trick, averted vision. The secret is to not look directly at the object, but slightly to one side. This brings the image onto a more sensitive part of your retina. If you still can't see it, try again another night from a darker site.

A little to the west of the Helix and slightly south lies **41 Aquarii**, a double star system with a pretty color contrast. The two components have spectral classes that straddle the Sun's: K0 and F8. Webb noted their colors as reddish and blue. The A star has a magnitude of 5.5, the B star 7.5, and their separation is some 5.2″ of arc — well in the range of even a small telescope.

Let's return to Zeta and use it as a jumping off point to our next object, the massive globular cluster M-2.

M-2 lies 1h of right ascension west of Zeta and a degree or so south of it. At magnitude 7, and situated in a "stellar desert," you'll find it with little trouble.

Its diameter on photographs is about 11′ of arc; visually it looks about two or three minutes smaller. The proportional difference is less than with many globulars for M-2 is one of the most tightly condensed of all. Packed into a ball some 150 light-years in diameter, the total stellar population here is probably over 100,000; M-2 lies about 50,000 light-years away.

Webb described it as "granulated" and quotes Sir John Herschel's comparison of it to a heap of fine sand. Another observation likens it to a swarm of luminous bees — a view which poor seeing will certainly enhance. John Mallas saw a dark lane curving across the cluster's northeast quadrant using his 4-inch refractor. Moderate powers with a 6-inch will start the edges resolving into stars, and the view gets steadily better as you increase the aperture.

For our last three items, we must find our way down to the south of the western water jar. There, near 21h right ascension and -13° declination lie another globular cluster, a tiny "non-object" that somehow made it into Messier's catalog, and a fine planetary nebula.

The globular cluster is **M-72**. Situated about 2.5° south and 6m of right ascension east of fourth magnitude Epsilon (ε) Aquarii, M-72 is not a striking object. Even Webb, who seems at times to have snapped up anything in the reach of his scope, ignored it.

In truth, the view will show only a small, round patch of fuzz, 2′ of arc across and of 9th magnitude. It will have a granular or mottled appearance, although numerous observers mention how difficult it is to make that final step and actually resolve it into stars. Anything so loose, they feel, ought to resolve better. What do you think?

Five minutes of right ascension east and 6′ of arc south lie three little 10th magnitude stars and an even fainter fourth that make up the "cluster" of **M-74**. Frankly, most observers find M-74 a disappointment. Well, let's tick it off and silently agree with Smyth's annotation, "I give it out of respect to Messier's memory."

Our last object on this month's list definitely offers more (though M-74 isn't exactly a tough act to follow): NGC-7009, a planetary nebula bearing the nickname the "**Saturn Nebula**." Found by sweeping 5m of right ascension due west from 4th magnitude Nu (ν) Aquarii, it will appear in your eyepiece as an 8th magnitude oval bluish spot measuring 45″ of arc by 25″.

A look at a photograph shows how the nebula got its nickname: two "spikes" extend from the ends of the oval, making it look very much like Saturn does at present, with the rings nearly edge-on. Curiously, the name was conferred after naked-eye observations by the Earl of Rosse. Edward Holden said that it looked like an "elastic link which has been warped" and noted that the "two satellites preceding and following nearly in the major axis of the nebula appear to be faintly connected with the main nebula."

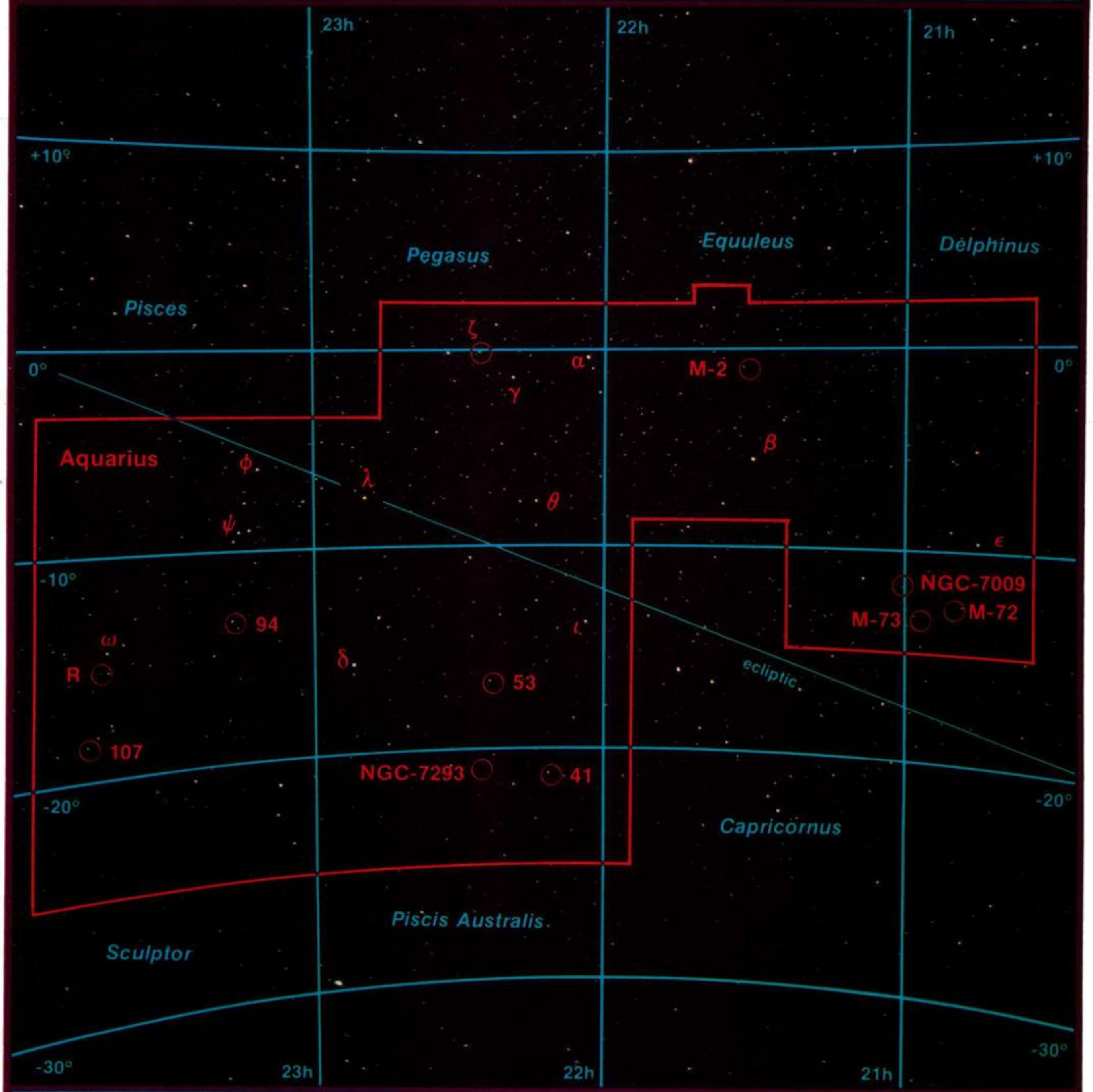
The cloud of gas surrounding the 12th magnitude central star has a (major axis) diameter of about half a light-year, but with the distance to the nebula pretty uncertain, not too much weight should rest on that figure.

Aquarius may be a dim, somewhat barren constellation to the naked eye, but it certainly doesn't lack worthy objects. Anyone who explores it with a telescope will return home having viewed some very fine sights.

photo by Brad Wallis & Robert Provin

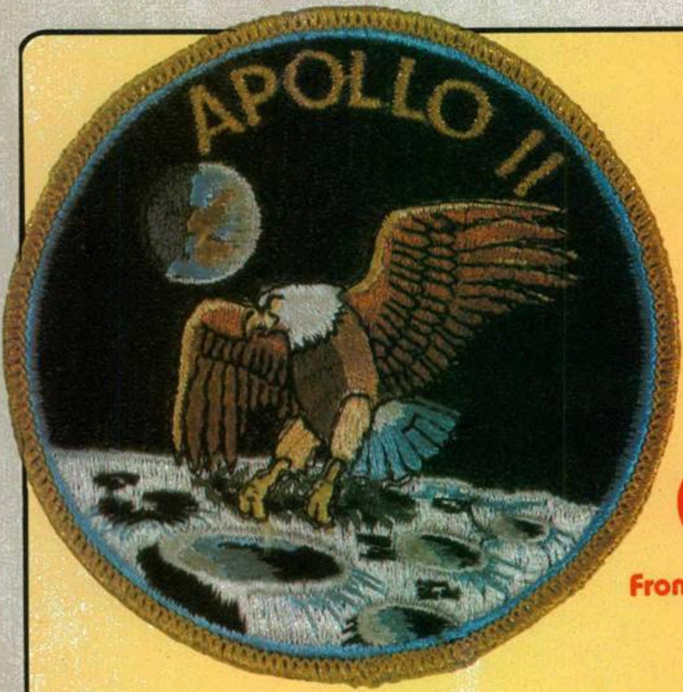
aquarius

map by Robert Burnham


23h
22h
21h
+10°
+10°
Pegasus
Equuleus
Delphinus
Pisces
ζ
α
M-2
0°
0°
γ
β
Aquarius
φ
λ
θ
ψ
ε
-10°
NGC-7009
M-73
M-72
94
ι
ω
δ
R
53
ecliptic
107
NGC-7293
41
-20°
-20°
Capricornus
Piscis Australis
Sculptor
-30°
-30°
23h
22h
21h

Object	Type	Mag.	Size/Sep. Per.	R.A. (1950) Dec.		R.A. (1981) Dec.	
M-72	●	9.2	2′	20h51m	-12°44′	20h52m	-12°37′
M-73	○	10	1′	20h56m	-12°50′	20h58m	-12°43′
NGC-7009	■	8.4	45″x25″	21h01m	-11°34′	21h03m	-11°27′
M-2	●	7.0	8′	21h31m	-01°03′	21h33m	- 0°55′
41	★^{2}	5.5,7.5	5.2″	22h12m	-21°19′	22h13m	-21°10′
53	★^{2}	5.7,6.4	6″	22h24m	-17°00′	22h26m	-16°51′
Zeta (ζ)	★^{2}	4.4,4.6	1.8″	22h26m	-00°17′	22h28m	- 0°07′
NGC-7293	■	6.5	15′x12′	22h27m	-21°06′	22h29m	-20°53′
94	★^{2}	5.3,7.5	13″	23h16m	-13°44′	23h18m	-13°33′
R	ɱ★	5.8-11.5	387d	23h41m	-15°34′	23h43m	-15°23′
107	★^{2}	5.7,7.0	6.5″	23h43m	-18°57′	23h45m	-18°47′

★	*Star*
★^{2}	*Double Star*
★^{3}	*Triple Star*
ɱ★	*Regular Variable*
∩★	*Irregular Variable*
ʜ★	*Eclipsing Variable*
○	*Open Cluster*
●	*Globular Cluster*
■	*Planetary Nebula*
□	*Bright Diffuse Nebula*
§0	*Elliptical Galaxy*
§S	*Spiral Galaxy*
§ʃ	*Barred Spiral Galaxy*
§#	*Peculiar/Irregular Galaxy*



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PRICE ANNOUNCEMENT

The C5 Telescope will be going up in price effective September 15, 1981. Please contact your nearest Celestron dealer for pricing information.

The Double Star Cluster Perseus

M8, The Lagoon Nebula in Sagittarius

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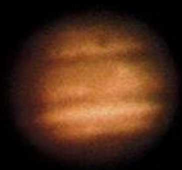
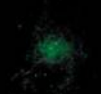
SATURN

M17



JUPITER



M33

The Moon

While there is no substitute for the brilliance, detail and clarity of the superior images offered by a well made, optically large telescope, extreme portability is sometimes as much a factor in selecting a telescope as is larger aperture performance. The Celestron 5 offers extreme portability at an aperture large enough for serious astronomical observing and photography.

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